APPLEBY'S HANDBOOK OF MACHINERY

SECTION 2.

HOISTING MACHINERY.

APPLEBY'S
ILLUSTRATED HANDBOOK
OF
MACHINERY.

SECTION II.—HOISTING MACHINERY,

INCLUDING

WINDING ENGINES, HYDRAULIC, STEAM AND HAND CRANES, WINCHES AND JACKS.

WITH

PRICES, WEIGHTS, MEASUREMENTS, AND SOME DATA ON WORKING EXPENSES AND RESULTS OBTAINED.

BY

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(APPLEBY BROS.)

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The Edition of Appleby's Hand-book of Machinery, published in 1869, and several reprints of it having been exhausted, a New Edition (of which this section forms a portion) is now being completed; and for the convenience of those who desire information on specific subjects, but not on all those treated, the book will be divided into eight sections, each of which may be obtained separately as follows:—

Section 1.—PRIME MOVERS.

Steam, Gas and Air Engines, Boilers, Turbines, etc.

Section 2.—HOISTING MACHINERY.

Winding Engines, Hydraulic, Steam and Hand Cranes, Winches and Jacks.

Section 3.—PUMPING MACHINERY.

Pumping Engines, Centrifugal, Steam and Hand Pumps.

Section 4.—MACHINE TOOLS.

For Working Metals, Wood, etc.

Section 5.—CONTRACTORS' PLANT AND RAILWAY MATERIALS,

Including the Machinery and Materials required for the Construction and Equipment of Railways and other Public Works.

Section 6.—COLONIAL AND MANUFACTURING MACHINERY.

For Treating Corn, Coffee, Rice, Sugar, Cotton, and other Products, Oil Mills, Gas Works, etc.

Section 7.—MISCELLANEOUS IRON WORK.

Brass Fittings, Engineer's Tools, and General Stores.

Section 8.—USEFUL TABLES AND MEMORANDA.

For Engineers, Merchants, and Manufacturers, with Prices, Weights, Measurements, Working Results, Cost of Working, etc.

The complete work will form two volumes of about 900 pages, illustrated by nearly 700 Engravings.

The subject matter has been almost entirely rewritten, and the Engravings illustrate for the most part work designed or carried out by the Authors' Firm, and now in successful operation. Details of design, construction, and proportions will be subject to modification from time to time.

The Prices have been corrected up to date, and are based on the present value of metals and labour: they will therefore necessarily be subject to modification if there should be any material change in the value of these items.

Weights and measurements are given approximately, so that the cost of freight, duty, &c., may be roughly estimated; also some data as to the cost of working, the motive power required, and the work performed.

The cost of packing for shipment and delivery to docks varies with the nature of the packing required and the destination, but the average is—

For packing and delivery alongside vessel in		London	about 3 per cent.
ditto	ditto	Liverpool or Hull ..	about 5 per cent.
ditto	ditto	Cardiff or Glasgow ..	about $7\frac{1}{2}$ per cent.

The details above referred to are in a handy form for reference, and it is hoped they may prove useful alike to Engineers and to users and purchasers of Machinery and Materials connected therewith.

CONTENTS.

SECTION II.

HOISTING MACHINERY.

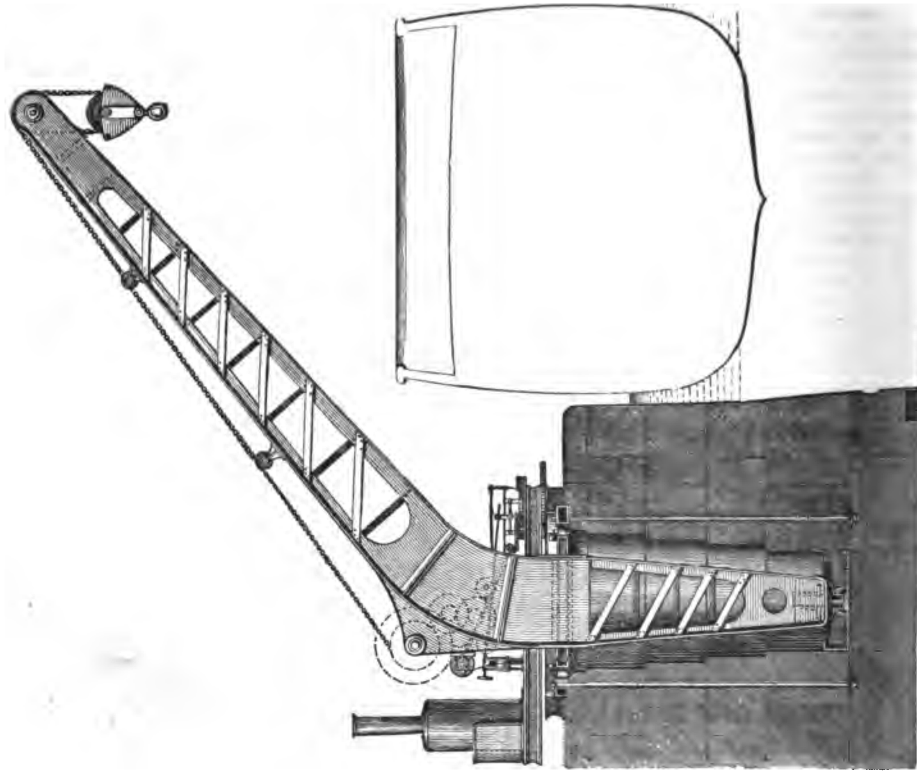


Fig. 102.

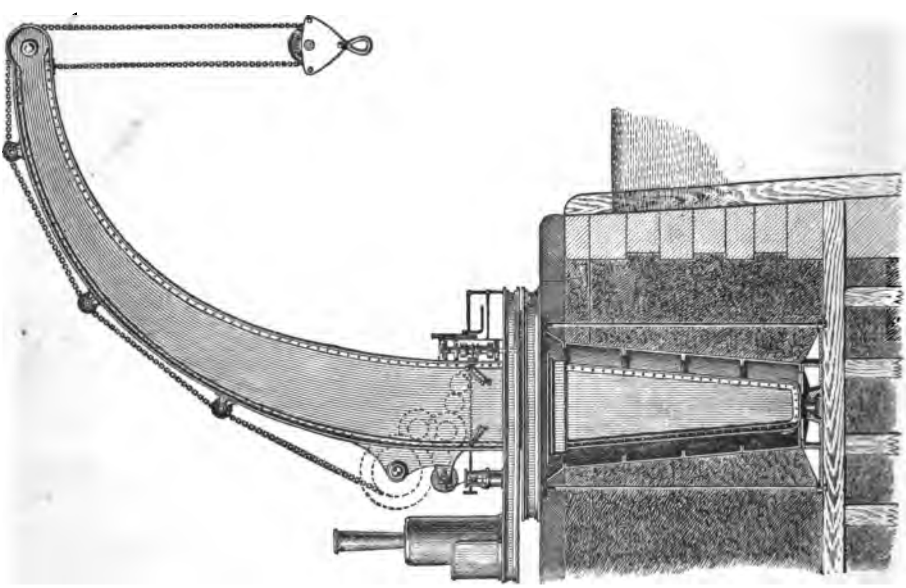


Fig. 101.

50-TON "FAIRBAIRN" STEAM CRANE. The crane illustrated Fig. 101, generally known as the "Fairbairn" crane, from the fact that it was originally designed by Sir William Fairbairn, in order to obtain great clearance under the jib-head for dealing with bulky packages, and for loading or discharging vessels of heavy tonnage, is constructed chiefly of wrought-iron: the box girder section gives the greatest strength with a minimum of material, and as this girder revolves, it always maintains the same relative position to the load; the continuity of the structure is also well preserved instead of the strains being divided between the jib, tie rods, framing, and post, as is the case in the form adopted for cranes of smaller power.

The necessary stability is obtained by the lower portion of the girder working in a circular pit of masonry, or, where a good foundation of masonry cannot be used, in a massive cast-iron cylinder of about 8 ft. diameter; there is a cast-iron plate at ground line, bolted to the foundations and bored internally, and at the bottom of the pit or cylinder there is a cast-iron socket to receive the pivot which is fitted to the foot of the curved girder or jib; hardened steel washers working in oil being interposed to reduce and distribute the friction over a large area. The girder or jib is also fitted with a casting turned on its vertical face and about 6 ft. diameter, and between this casting and the bored internal ring above referred to, a live ring of rollers about 12 in. diameter is interposed, those directly in line of the greatest strain being of steel; the enormous strain is thus distributed over a large number of friction wheels and a correspondingly large area of the foundation plate or ring. In some situations it is convenient to raise the masonry or cast-iron cylinder above the ground line, either from difficulty in obtaining foundations or to raise the jib-head to a greater elevation.

The arrangement of engines, boiler and gearing does not materially differ from the ordinary steam cranes, except that the first motions are all transmitted from the engines through a set of friction clutches and worm and tangent wheels, and the lifting gear is fitted with three powers in addition to the chain and blocks at the jib-head; the slewing or turning motions are also fitted with two speeds, and can be manipulated together with the load without stopping or reversing the engines. The barrel is grooved spirally to take the whole length of chain without an overlap, and the chain barrel shaft is driven from both sides by double gearing. Double hand shafts can also be provided, so that the crane can be worked in all motions when steam is down and only a single lift required, and the double hand shafts enable a large number of men to be employed without crowding. If it is desired to take steam from a fixed boiler, the steam pipe leads through the pivot to the engines, or the crane may be driven by a pair of hydraulic engines, and the pressure pipe conveyed to them in the same manner as if steam were used; many hand cranes of this type have been converted to work by steam or hydraulic power in the manner referred to. The condition as to radius and height of these cranes being always suited to their special requirements, it is somewhat difficult to quote prices but the following may be taken as an average both as to dimensions and cost of cranes of the type of Figs. 101 and 102:—

Power of crane	30 tons	40 tons	50 tons	60 tons	80 tons
Radius of jib	25 ft.	30 ft.	35 ft.	45 ft.	50 ft.
Height of jib head	35 ft.	35 ft.	40 ft.	50 ft.	60 ft.
Prices without boiler or tank	£2050 0 0	£2900 0 0	£3000 0 0	£3500 0 0	£4200 0 0
Prices with boiler complete	£2200 0 0	£3100 0 0	£3200 0 0	£3700 0 0	£4400 0 0
Price for iron housing ..	£35 0 0	£40 0 0	£40 0 0	£45 0 0	£50 0 0
Price for covering boiler ..	£15 0 0	£20 0 0	£20 0 0	£25 0 0	£25 0 0
Approximate weight	50 tons	65 tons	80 tons	100 tons	130 tons

The above prices are exclusive of the cast-iron caisson generally used in peaty or unsound ground, and the cost of these may be estimated at about £18 to £20 per ton, including fitting, facing, and bolts ready for fixing.

The engraving Fig. 102, page 2, is a modification of the "Fairbairn" type, the crane being straight from the point above the gearing to the jib-head sheaves, and instead of the solid web plates, the top and bottom members are connected by transverse ties and diagonal bracing as shown. This construction is somewhat more economical in material than the solid web plates, but being more expensive in construction, the cost is about equal. An advantage may sometimes arise, when required for shipment, as the freight would be lower, and the chain can be taken direct to the chain barrel; in cranes of the heaviest kind a double set of chains are employed.

20-TON FIXED STEAM WHARF CRANE. The crane, Fig. 103, page 3, is designed for lower powers than 30 tons, the cost of the Fairbairn type being higher without, in the large majority of instances, any commensurate advantage being obtained.

The two steam cylinders 7 in. diameter × 10 in. stroke are fixed vertically, and are fitted with case-hardened link reversing motions; the lifting gear is of two powers, the third power being

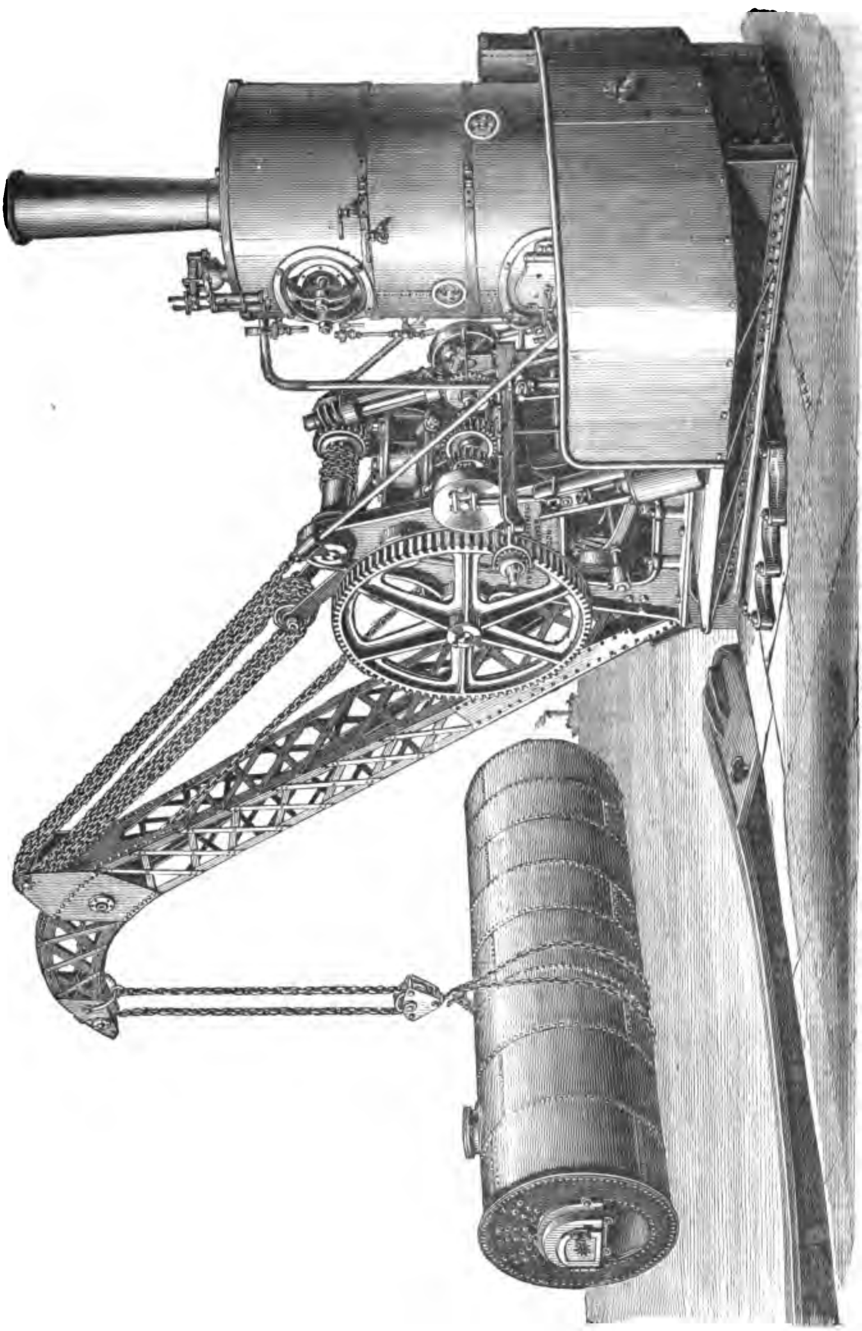


Fig. 103.

obtained by a block with the chain reefed to the jib-head. The single gear is proportioned to work loads up to 5 tons at quick speed, the double gear 8 tons at a lower speed, and the maximum load of 20 tons is lifted with the double chain and block. The turning motion has two speeds, so that the operations of lifting and turning are in unison with each other, and it is transmitted from the engine-shaft by a set of bevel wheels and double friction cones put into contact by a powerful eccentric lever. Motion is thus given to *a pair* of friction wheels immediately under the foot of the crane jib and distributing the thrust due to the load over a large area of the turned roller path on the foundation plate. Plain friction surfaces present many advantages over toothed gear for turning, especially when working at a high speed or at a long radius, toothed gear being very frequently broken when the load is set in motion or stopped too suddenly, whilst with friction surfaces the wheels slip on the roller path until the jib is brought to rest.

The crane may be fitted with rigid tie bars, but the derrick motion shown is invaluable when a variable radius is required, as, for instance, to reach the centres of vessels of different beam, or to obtain a height necessary for dealing with exceptionally bulky packages. This motion is transmitted from the crank shaft by a pair of bevel wheels to a vertical shaft with a worm on its upper end, driving a tangent wheel on the end of a chain barrel, the chains being double and in duplicate.

The crane post is of hammered scrap iron, turned to receive the superstructure, and to be fitted and keyed into the massive iron foundation plate. When steam is supplied from a stationary boiler, the post is bored down the centre and fitted with a steam gland at top and a steam-pipe connection below the base plate.

The boiler is usually carried on a feed water tank, which is fixed behind the crane, and forms a platform for the attendant as well as a useful counterpoise to the load. The hanging tube type is preferred, but a vertical multitubular or a plain cross tube boiler will be supplied if desired. In all cases the boilers are of ample proportion, and are fitted with all the usual mountings and of the most improved kinds, including double safety valve, steam pressure gauge, and fusible plug in the crown of the fire-box. The feed pump is worked from the engine shaft, but a separate donkey pump or an injector will be supplied at an extra cost of from £15 to £23. Sufficient best tested short link crane chain is supplied to reach 15 feet below ground line when the double chain and block are used.

The whole of the motions can be worked by hand power when steam is down, which is sometimes a great advantage.

Foundation bolts are included in the subjoined prices, and the cost of packing for shipment is from 2 to 3 per cent. on those prices:—

Power of crane, Fig. 103	15 tons	20 tons	25 tons
Radius of jib at 45°	16 ft.	18 ft.	20 ft.
Steam cylinders, two	7 × 10 in.	7½ × 10 in.	8 × 12 in.
Price of crane without boiler	£895 0 9	£1245 0 0	£1740 0 0
" with boiler and tank ..	£975 0 0	£1350 0 0	£1850 0 0
" extra if with derrick jib ..	£40 0 0	£45 0 0	£50 0 0
" " if with iron jib ..	£25 0 0	£30 0 0	£35 0 0
" " if with curved iron jib	£30 0 0	£35 0 0	£40 0 0
" " if with iron housing ..	£30 0 0	£30 0 0	£35 0 0
" " if boiler is covered ..	£20 0 0	£20 0 0	£25 0
Approximate weight	20 tons	25 tons	30 tons
" measurement	800 cubic ft.	950 cubic ft.	1100 cubic ft.

The radius of jib above given has been taken as a standard, but it can be modified to suit special cases.

The type of crane, Fig. 104, page 6, No. 29, is, with, but slight modification, constructed of all sizes from 3 to 10 tons' power. The following description, however, refers to a 10-ton crane with two steam cylinders 7½ in. diameter × 10 in. stroke, fixed in an inclined position on the outside of each side frame. The steam ports pass through the frames, and the slide valve chests are on the inner sides of the frames; the guides to the pistons are cast to the top cylinder covers, and are truly bored to receive the slide blocks, the wearing surface being very large; the blocks cottered to the steel piston rods receive the lower end of the connecting rods, which are of wrought iron, fitted with gun-metal steps at slide block end and cross cotter to take up the wear; the crank-pin ends are of the marine pattern. The crank shaft is fitted with a pair of turned balanced disc plates, into which the crank-pin ends are rivetted; inside the frames are the eccentric sheaves, with gun-metal straps, and the reversing motion is of the shifting link type; the crank shaft and all the high speed shafts are, as far as possible, fitted with gun-

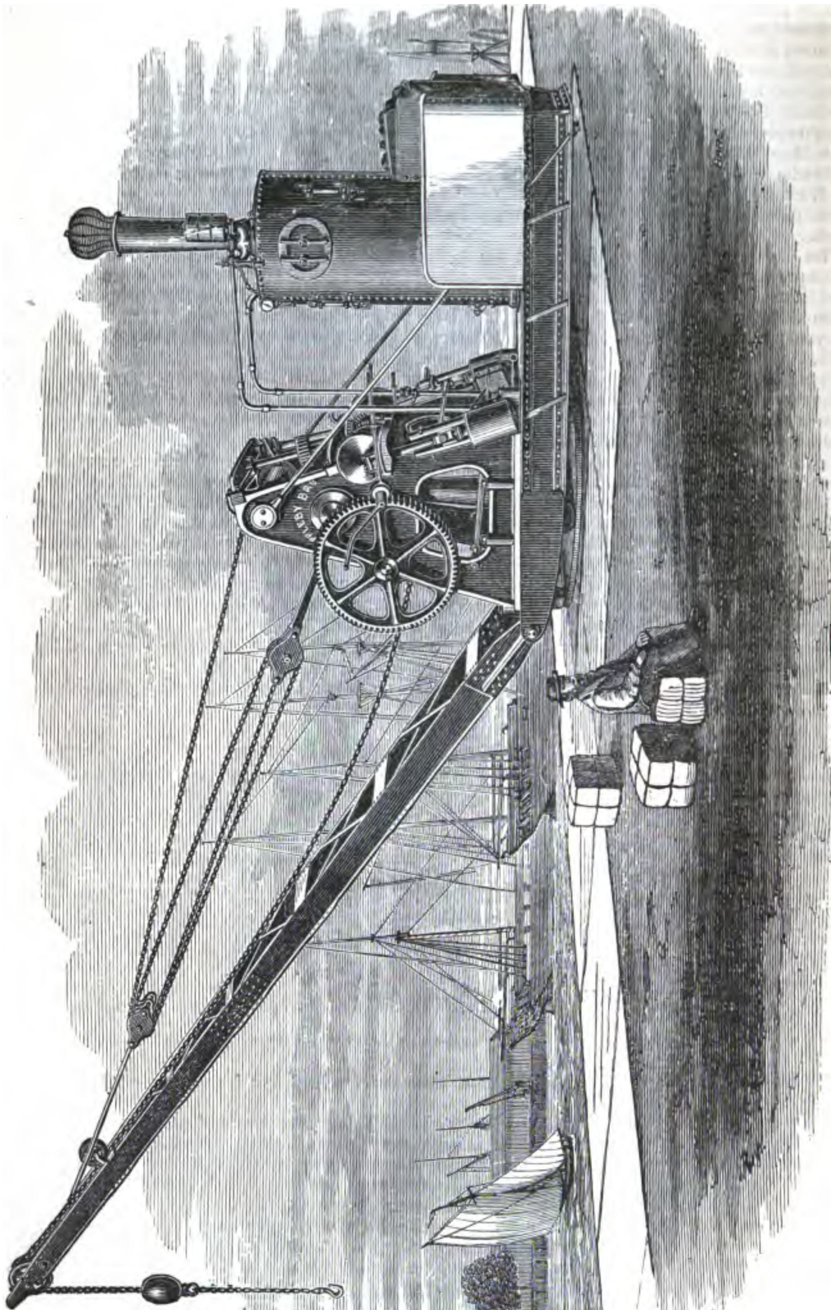


Fig. 104.

metal bearings, loose caps, and lock nuts; the motions for lifting, turning and altering the radius are taken from the crank shaft. The lifting power is single and double purchase, and the barrel shaft is fitted with a friction strap brake for lowering; for the third power, a running block and double chain to the jib-head is used when lifting the maximum load of 10 tons. The turning or slewing motion is transmitted from the intermediate shaft by a set of bevel wheels and double friction cones (the power and speed of slewing being altered simultaneously with the corresponding lifting power), and a vertical shaft and train of bevel gear transmits motion to two large friction wheels which are almost directly in the line of thrust of jib; the axis of these radiate to the centre of the crane, and travel on a turned path on the foundation plate. The friction cones are put into contact by a powerful eccentric hand lever, and the slewing motion can be worked in either direction whilst lifting or lowering the loads, and without stopping or reversing the engines.

The derrick motion is taken from the engine shaft by a pair of bevel wheels driving an oblique shaft, with a cast steel worm on the top, gearing into a tangent wheel on the chain barrel, around which coils the single chain of the double sheave blocks leading from the top stretcher of the crane framing and jib-head pin; the worm and tangent gear sustaining the jib in any required position when the first motion wheels are disconnected from the engines.

The whole of the engines and gearing are mounted on a pair of cast-iron side frames and revolving base; a wrought-iron feed water tank is bolted to this base, forming the foot-plate for the driver and support for the steam boiler, which is placed well back to assist in counterbalancing the load; the sides of the boiler are fitted with coal bunkers. The crane post is of hammered scrap iron, extending a considerable distance below the ground line, and when the crane is driven from a stationary boiler, the post is made hollow to convey steam to the engines through its centre; the post is fitted with a massive cast-iron plate at the ground line, and a toe plate at the lower end of the post, holding down bolts passing from the lower to the top plate, and securing the whole mass of masonry well together.

The crane-jib is of iron, composed of side plate and angle irons braced together with lattice bracing, sometimes curved, as shown in the engraving of portable crane, Fig. 117, page 27; this entails a little additional expense, but is sometimes very convenient. Wood jibs are, however, generally used, and, being both light and stiff, are recommended for cranes of this and smaller powers, excepting when a curved jib is required, or the crane is for use in an exceptionally hot climate.

The boiler is of the vertical type, 3 ft. 6 in. outside diameter, 7 ft. high, and is fitted with two cross tubes. This form of boiler, although not the best for economy of fuel, has the advantage of being simple in construction and not liable to get out of order, even when working with bad water, which is often of more importance than some saving of fuel with a complicated and expensive boiler. The boiler has all the usual fittings, and is connected to the crane engines by steam pipes; the feed water is taken from the water tank by a hollow plunger feed pump, worked by an eccentric on the crank shaft, and a cock and check valve are placed between the pump and the boiler.

The principal differences between the crane above described and the smaller sizes are those of proportion and radius; the latter have only one friction wheel under jib, and the smallest sizes are only single purchase.

The prices of the various sizes, fitted with or without boiler, &c., will be obtained from the subjoined table; the radius given is that upon which the strains have been calculated, and if it is desired to increase the radius of any crane, the load must be proportionately decreased, or a heavier crane be taken to do the work.

Power of crane, Fig. 104 ..	3 tons	5 tons	7 tons	10 tons	15 tons
Normal radius at 45°	14 ft.	15 ft.	16 ft.	18 ft.	20 ft.
Number of cylinders	2	2	2	2	2
Diameter and stroke of cylinders	$6\frac{1}{2} \times 10$ in.	$6\frac{1}{2} \times 10$ in.	$7\frac{1}{2} \times 10$ in.	$7\frac{1}{2} \times 10$ in.	8×12 in.
Price of crane with fixed jib, without boiler or tank ..	£300 0 0	£400 0 0	£520 0 0	£720 0 0	£900 0 0
Price of crane with fixed jib, with boiler and tank ..	£400 0 0	£500 0 0	£650 0 0	£850 0 0	£1050 0 0
Price extra with derrick gear ..	£15 0 0	£20 0 0	£25 0 0	£30 0 0	£35 0 0
Price extra for iron jib	£10 0 0	£15 0 0	£18 0 0	£20 0 0	£25 0 0
" " for curved iron jib ..	£15 0 0	£20 0 0	£23 0 0	£25 0 0	£30 0 0
" " for iron housing ..	£20 0 0	£25 0 0	£28 0 0	£32 0 0	£35 0 0
" " for covering boiler ..	£15 0 0	£18 0 0	£20 0 0	£20 0 0	£25 0 0
Approximate weight	7 tons	10 tons	12 tons	15 tons	20 tons
" measurement ..	280 cub. ft.	400 cub. ft.	480 cub. ft.	600 cub. ft.	800 cub. ft.

These prices include foundation bolts. The cost of packing for shipment is 3 per cent.

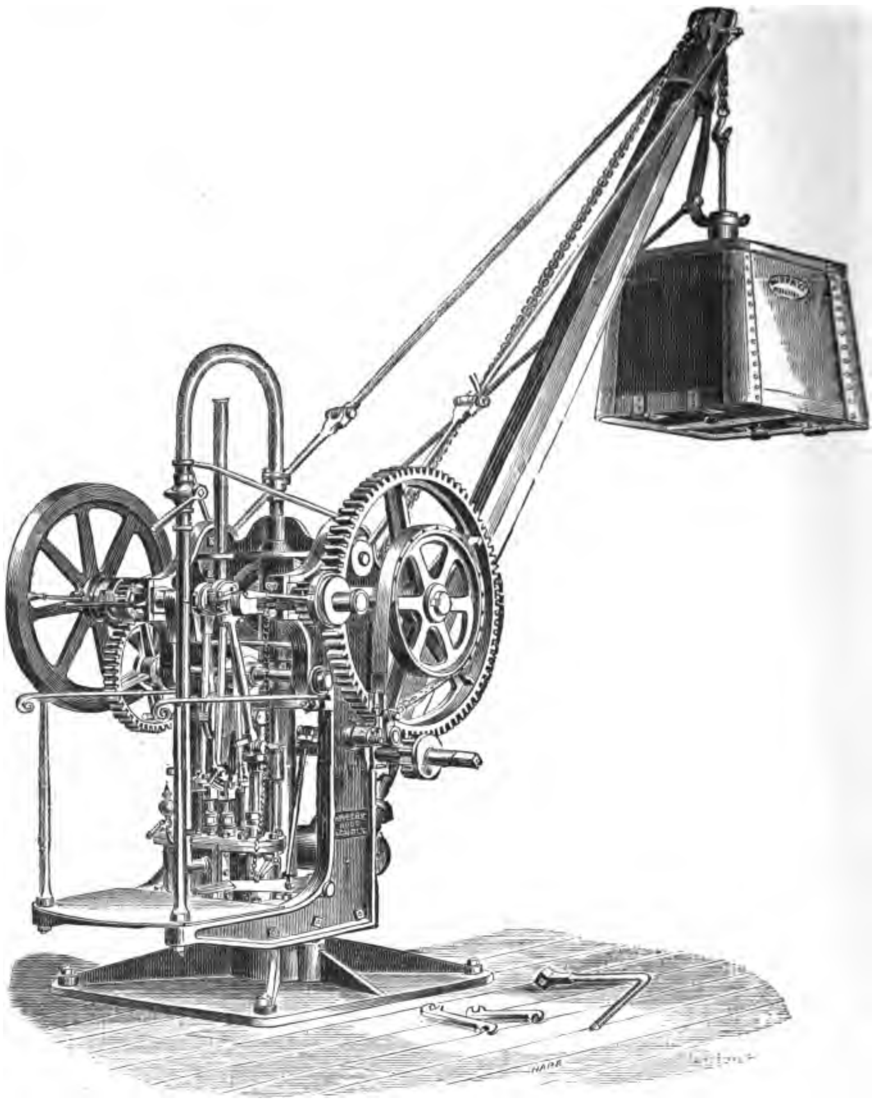


Fig. 105.

The **SHIP'S DECK** or **WHARF CRANE**, Fig. 105, No. 10, is very quick in action, and is constructed to occupy the minimum of space; steam is supplied from the main boiler of the vessel or factory, or from a separate boiler of sufficient power for several cranes or winches. Sometimes the boiler is fixed behind the crane, and swings with it, as shown Fig. 104, but this arrangement should, if possible, be avoided, cranes of this type being specially designed to work quickly with light loads at a short radius and to take the steam from a fixed boiler.

The engines have link reversing motions; the lifting gear is single or double purchase, as specified below, and is fitted with a powerful strap brake worked by the foot for lowering. The turning motion is transmitted through double friction clutches, and the crane will turn in either direction whether it is lifting or lowering, without stopping or reversing the engines.

The speeds of lifting and turning are arranged to make a lift, turn one-third of a circle, and lower the load in about 30 seconds.

The crane post is of hammered scrap iron of sufficient length to reach the lower deck or keelson of a vessel or a similar depth below quay level, but on board ship the post should be carried down as low as possible in order to relieve the deck from excessive strain. The post is bored hollow above the foundation plate, the steam being carried into it at or slightly below that level, and passing through a gland at the top of the post to the steam cylinders. The exhaust steam can be carried back through the post to water level or to any convenient point; this entails a slight additional expense, but it effectually gets rid of the discomfort caused by the escape of exhaust steam, especially in cold weather, as well as the risk of damage to goods or cargoes, causing decks to become leaky, &c. The jib is made to be readily unshipped whilst the vessel is at sea, and the crane secured from turning on its post. Hand shafts and handles are provided for working the crane by manual power, also chain to reach 20 ft. below the deck line. The subjoined list of prices includes 8 ft. of crane post below floor level, and the cost is given for any additional length which may be required.

For boilers suitable to supply steam to one or more cranes, see page .

Power of the crane ..	1½ ton	2 tons	3 tons	4 tons	5 tons
Diameter and stroke of engines, two ..	5 × 9 in.	6 × 10 in.	7 × 10 in	6 × 10 in.	7 × 10 in.
Number of purchases ..	Single	Single	Single	Double	Double
Radius of jib	12 ft.	13 ft.	13 ft.	14 ft.	14 ft.
Length of crane post below deck ..	8 ft.	8 ft.	8 ft.	8 ft.	8 ft.
Approximate weight ..	2 tons 15 cwt.	3 tons 10 cwt.	4 tons 10 cwt	5 tons	5 tons 15 cwt.
Price complete, as described	£180 0 0	£200 0 0	£225 0 0	£275 0 0	£325 0 0
Price extra for exhaust through post ..	£5 0 0	£6 0 0	£7 0 0	£8 10 0	£10 0 0
Price extra per foot for post beyond 8 ft. long	£0 10 0	£0 15 0	£1 0 0	£1 5 0	£1 10 0

The **STEAM WAREHOUSE HOIST**, Fig. 106, page 10, for attaching to a crane or lift, combines the most recent improvements made in this class of machinery, the loads being worked at a very high speed with great safety by a chain coiling on a barrel on the engine shaft without any gearing or break. A pair of vibrating steam cylinders proportioned to the load and the steam pressure available are coupled at an angle of 90° to the barrel shaft; the cylinders are fitted with an improved valve reversing motion, the steam being admitted and controlled by a central valve, which passes the steam to the top or bottom of the piston, as may be desired, or shuts it off completely. A rod leading to each floor where the lift has to be worked is attached to this valve, and by means of a lever, on any or each floor working this rod the operations of lifting, lowering, or stopping, are under entire control. When the lever is in a central position, the steam is shut off, and the hoist stops; when raised, the load is raised, and when lowered, the load descends; the speed of either operation being in proportion to the travel of the valve. When it is full open, a great speed will obviously be obtained, because the chain barrel makes the same number of revolutions as the engines. The chain barrel being usually about 8 in. diameter, if the engines make 100 strokes per minute, the chain will travel at a speed of about 200 ft. per minute ; in practice, however, this speed is much exceeded, yet the controlling power is so great that the load can at any moment be stopped within an inch of the point required, nor are goods damaged by being seized too suddenly; the attendant starts very gently, and immediately the load is han ging clear, he opens the valve, and runs up the load at full speed.

The gear shown in the engraving is only used when heavy loads have to be lifted; at other times it is thrown out by an eccentric shaft in a similar manner to the back gear of a turning lathe; but as nine-tenths of the loads can be lifted by steam direct, comparatively few are fitted with this apparatus, although it is very useful when no other appliances exist for dealing with an occasional heavy lift. The steam hoist is bolted to a wall or to the timbers of a lift, the chain being led to the crane jib or cage of lift.

Some improvements having recently been made, this description does not entirely coincide with the engraving, but the general appearance is the same, and the foregoing description is correct.

A number of these hoists are frequently used in one establishment, one to each crane, jib, or hoist, steam being supplied from a boiler fixed in any available place, such as a Cornish boiler in a fire-proof room in the basement or a vertical boiler carried on cantilevers outside the building. Another neat arrangement is to place the whole of the machinery and boiler on cantilevers outside

a warehouse, directly below the crane jib, and surrounded by an iron house from which the attendant works the crane. This avoids any connection between the engine-house and warehouse, and reduces to a very small amount the premium to be paid for fire insurance, but in laying out new buildings, the Cornish boiler and fire-proof room should be adopted. The price of boilers will be found at pp. 55 to 64, Section 1, and of crane jibs, page 46, Section 2. Steam-pipe and branches can be carried many hundred feet when well protected without trouble and with but very slight loss.

PRICES, &c. OF STEAM HOISTS, Fig. 106.

Power of crane direct at 45 lbs. steam	7 cwt.	10 cwt.	15 cwt.	20 cwt.	30 cwt.
Power of crane geared at 45 lbs. steam	14 „	20 „	30 „	40 „	60 „
Diameter and stroke of cylinders	6 × 12 in.	7 × 12 in.	8 × 12 in.	9 × 15 in.	10 × 15 in.
Diameter and length of chain barrel	7 × 36 in.	8 × 36 in.	8 × 36 in.	8 × 36 in.	9 × 36 in.
Price of crane, not geared ..	£70 0 0	£80 0 0	£90 0 0	£100 0 0	£120 0 0
„ „ geared ..	£90 0 0	£105 0 0	£120 0 0	£130 0 0	£155 0 0
Approximate weight	1 ton	1 ton 5 cwt.	1 ton 15 cwt.	2 tons	2 tons 15 cwt.

The cost of chains and levers is not included in the prices above quoted.

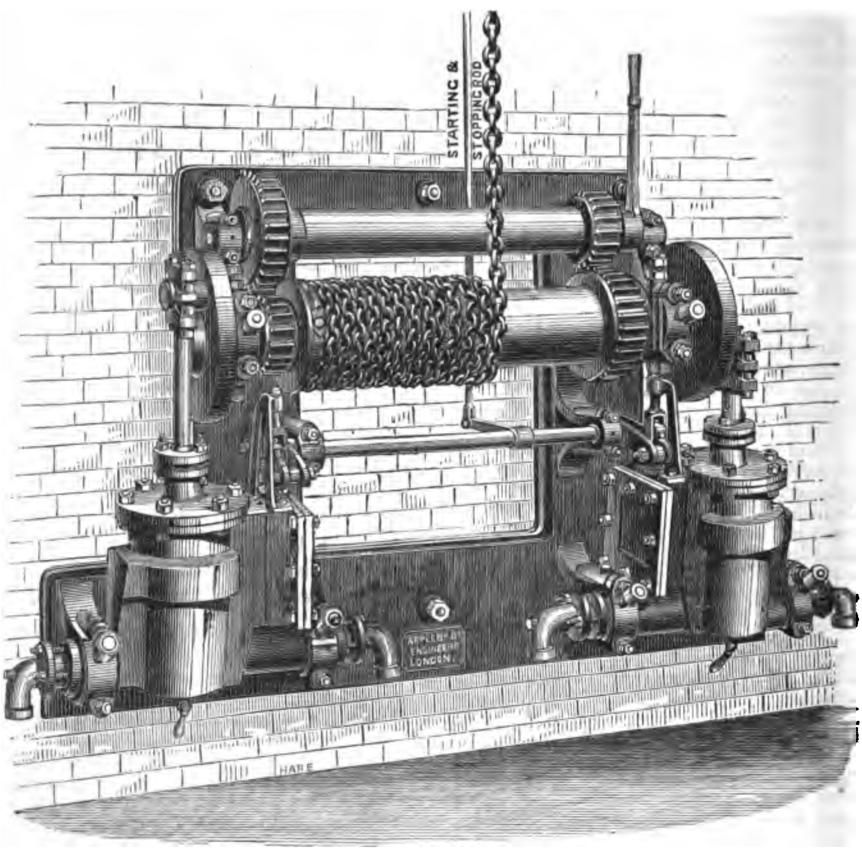


Fig. 106.

This system of hoist can be worked by water or compressed air; in the former case, a greater area of the pipes, passages, &c. is allowed, and where a natural head of water can be obtained, or in towns where the high-pressure constant service is in use, a more convenient motor cannot be imagined. Compressed air can be used instead of steam, and it has some advantages over steam or water, there being no loss from condensation nor bursting of pipes from frost, &c., and damage to stock likely to follow. It can, moreover, be carried to an unlimited distance without loss or inconvenience. For prices and description of compressors, see Section 5.

The special advantages claimed for this system are: high speed and noiseless working; great safety and simplicity; all gear brakes and clutches being dispensed with, and one lever only being used; non-liability to get out of order.

STEAM WAREHOUSE CRANE. In some situations the crane, Fig. 107, is more convenient than that last described, because it can be worked either by hand or steam power, the crank shaft being used as the hand shaft, when the piston rod is disconnected. These cranes are fitted with single purchase for loads up to about 1 ton, and double purchase gearing for cranes above that weight. The single steam cylinder is of the same type as that described for hoist, Fig. 106, and is fitted with the same reversing arrangement, the crank being kept from standing on its dead point by a counterbalance in the fly-wheel rim; or should it stand on the centre with a load, it can always be started by reversing the valve.

Many hand cranes have been altered to work by steam in this manner, and have given good results; this, however, can only be obtained with a crane well designed and substantially built in the onset.

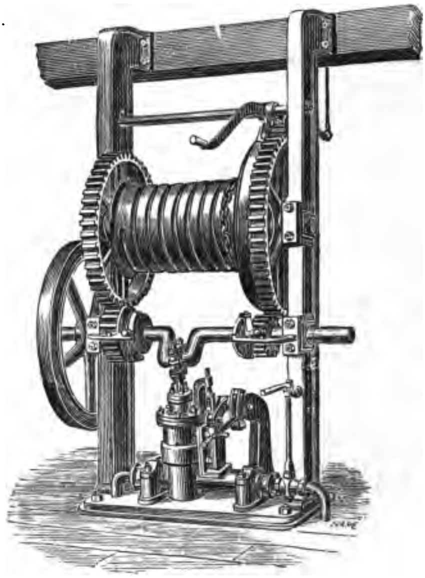


Fig. 107.

Power of crane	10 cwt.	15 cwt.	20 cwt.	30 cwt.	40 cwt.
Single or double geared	Single	Single	Single	Double	Double
Diameter and stroke of cylinder	6 × 12 in.	7 × 12 in.	8 × 12 in.	6 × 12 in.	7 × 12 in.
Price of crane	£55 0 0	£60 0 0	£65 0 0	£75 0 0	£85 0 0
Approximate weight	1 ton	1 ton 5 cwt.	1 ton 10 cwt.	1 ton 15 cwt.	2 tons
„ measurement ..	50 cub. ft.	60 cub. ft.	65 cub. ft.	70 cub. ft.	75 cub. ft.

In preparing these prices it has been assumed that a pressure of 45 lbs. per square inch is available, and that the height of lift does not exceed 50 ft., also that the floor or beam, to which the top of the crane is attached, is not more than 10 ft. high; these cranes can, however, be readily modified to suit other conditions with a slightly increased cost.

Cranes of this type can also be worked by water or air, or by a boiler in which the steam is generated by gas, which requires but little attention, and can be used in places where the ordinary steam boiler would not be allowed without a great increase in the premium for fire insurance; in such cases, where the work is not considerable, and the value of the property warehoused is great, the gas boiler affords a valuable alternative.

For prices of these and other boilers, see Section 1, pages 55 to 64, and crane jibs, Section 2, page 46.

STEAM FOUNDRY CRANES. A great difference of opinion exists amongst the managers and foremen of foundries as to the system of crane power best adapted for use in foundries. Those advocating the swing crane system urge that the man or men engaged to work the crane can be profitably employed in assisting the moulders when the crane is not in use; the advocates for the overhead traveller system, on the other hand, point to the advantage of a clear moulding floor, and to the fact that the space within a radius of 8 feet from the centre of each swing crane cannot be occupied, and the traveller can carry

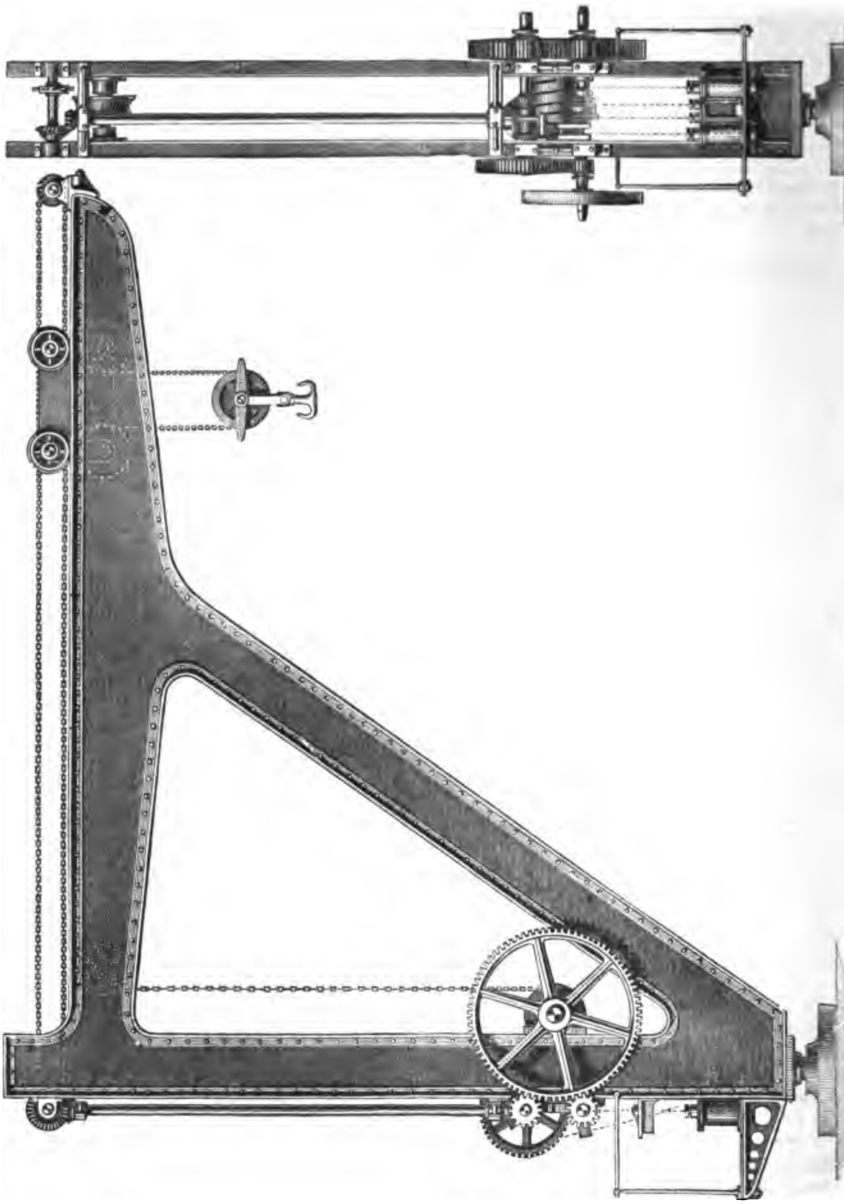


Fig. 108.

the boxes from the outside of the building and deposit them at any place within the space traversed, also that it as readily removes the castings to the trimming shop, or takes a ladle of metal from the cupola direct to any mould, whilst but few of these operations can be conveniently performed by swing cranes. A little consideration, however, suffices to show that each system has its advantages, and that the size and design of the foundry buildings, together with the work to be performed and the conditions to be fulfilled generally, will, in a great measure, govern which system should be adopted.

Fig. 108 is a good example of a fixed steam foundry crane. The main framing is constructed entirely of wrought iron, the sides being of plates stiffened at their edges by angle irons; this construction is only for the largest sizes, the smaller powers being made with plates having sufficient stiffness without angle irons. The crane shown in the engraving has two steam cylinders, with link reversing motions, single and double purchase gearing, and the barrel is grooved spirally to take the chain without an overlap and prevent the chain surging, return block and double chain, racking in and out motion to the jenny, and steam slewing gear. The smallest cranes have one steam cylinder, and are not fitted with the slewing gear. All are fitted with hand motions, so that in the event of any accident to the engines or steam pipes the crane can be worked by hand power, and thus save a cast. The largest cranes have double handle shafts.

The steam pipe to the cylinders is generally introduced through the top pivot of the crane, but in some cases through the bottom pivot; this, however, should be avoided, if possible; in other cases, where the crane is fixed near a wall, and does not require to swing more than about 180°, the steam pipe can be taken to the centre line of the crane by a jointed pipe without passing through the pivots; this plan was adopted with several large hand cranes to which steam was applied, or the boiler may be fixed on a tank or platform behind or at one side of the crane and revolving with it.

Power of crane in tons	3 tons	5 tons	10 tons	15 tons	20 tons	25 tons
Radius of crane from centre to extreme point	16 ft.	18 ft.	20 ft.	20 ft.	20 ft.	20 ft.
No. of cylinders, diameters and strokes	1, 6½×10 in.	2, 5×10 in.	2, 6½×10 in.	2, 6½×10 in.	2, 7½×10 in.	2 7½×10 in.
Price of crane ..	£140 0 0	£275 0 0	£400 0 0	£500 0 0	£600 0 0	£700 0 0
Approximate weight	2½ tons	5 tons	8 tons	12 tons	15 tons	18 tons
" measurement	250 cub. ft.	350 cub. ft.	450 cub. ft.	500 cub. ft.	500 cub. ft.	500 cub. ft.

FOUNDRY CRANE TO BE DRIVEN BY POWER. The general form and appearance of these cranes does not vary greatly from that illustrated in Fig. 108, the difference being that the motive power is given from a line of shafting, placed overhead in the tie beams or roof instead of by steam cylinders on the crane; the power from this line of shaft is transmitted to a vertical shaft passing through the top pivot, and from it the lifting and racking in and out motion is obtained; the slewing motion is given by a spur ring fixed to the head of the crane, and the whole of these motions are primarily taken from the main shaft by cross and open belts, the levers of which are carried down within reach against the wall or column of the building, and the crane can therefore be worked from the foundry floor All the motions of these cranes are also fitted to be worked by hand power, in case of a strap breaking or derangement to the main driving shaft.

Where a main line of shafting exists, or is necessary in a foundry, this will be found a good arrangement, and the price of these cranes is about 5 to 10 per cent. less than steam foundry cranes, but where shafting must be specially provided for driving the crane or cranes, the cost may be estimated at about equal to those above noted.

For price of power travellers, see Section 2, pages 63 to 73.

Hand foundry cranes, Section 2, pages 49 and 50.

Hand travellers, Section 2, pages 73 to 81.

STEAM DERRICKS. The derrick is a very great improvement on the old form of quarry crane, the radius and sweep of the jib being altered by a neat mechanical arrangement invented by Mr. Henderson, of the late firm of Fox Henderson, and used by that firm with great advantage in the construction of the 1851 Exhibition in Hyde Park. It is generally termed the "safety derrick," from the fact that the chain barrel for lifting the load is (when the radius of the jib is required to be altered) geared up to a fuzee chain barrel, to which the chains to the jib-head are attached; the proportions of this fuzee barrel and the gear are such that the strain on the derrick chain is balanced by the load on the lifting chain; and if the

clutches between the engine and the gear were withdrawn, the load and jib would remain in the same position in which they were before the breakage occurred. The derricks to which we have referred were, however, only for hand power, and the next improvement was the introduction of steam power for the lifting and turning motions.

The illustration, Fig. 109, is engraved from a photograph of a derrick designed and constructed for the Mount Sorrel Granite Company in Leicestershire. It is proportioned to lift loads of 10 tons with a sweep of 50 feet, and stands on the edge of the quarries, which are upwards of 100 feet deep, and has given excellent results. It is selected for illustration and description as being a recent and, perhaps, one of the best examples of this most useful type of crane.

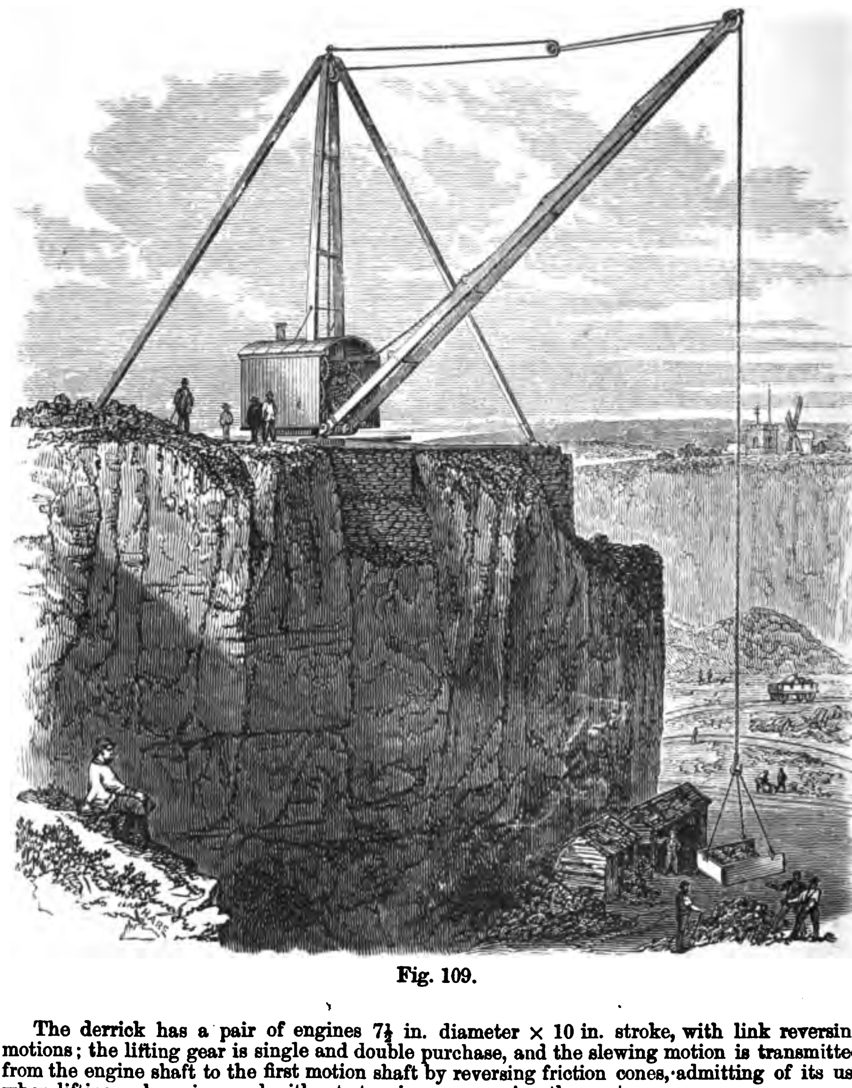


Fig. 109.

The derrick has a pair of engines 7½ in. diameter × 10 in. stroke, with link reversing motions; the lifting gear is single and double purchase, and the slewing motion is transmitted from the engine shaft to the first motion shaft by reversing friction cones, admitting of its use when lifting or lowering, and without stopping or reversing the engines.

The boiler is placed behind the driver, and is carried on a wrought-iron water tank, from which the feed water for the boiler is supplied, the feed pump being worked from the crank

shaft; the back end of the tank is stayed to the mast, the boiler is fitted with all the usual mountings, and the whole is protected by a corrugated iron house.

The timbers are of best pitch pine, the jib is double, and the back guys are trussed to the sleepers.

The above description will apply generally to other powers, excepting that the smaller sizes have one oscillating cylinder, and the jibs are of a single timber.

This crane has its own steam boiler, but one boiler is frequently used to drive a number of cranes, the steam being brought either through the bottom pivot, as shown in Fig. 110, or to a central point of the mast, so that the derrick can slew 280° without the cheeks of the mast fouling the pipe

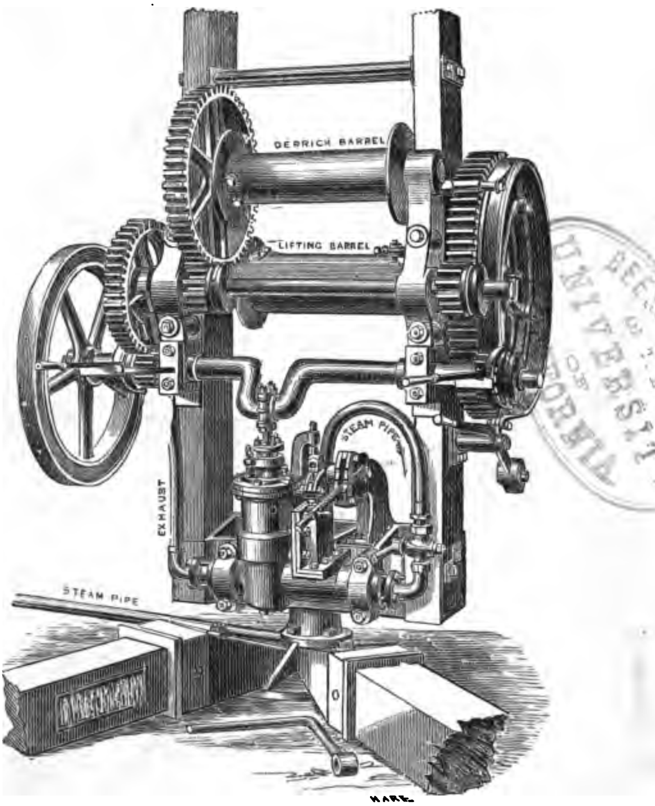


Fig. 110

The great area these cranes can cover, their moderate cost, and the great height of jib, together with the facility which the construction affords for moving and re-erecting, render them specially useful to contractors, builders, quarry-masters, &c. The relative value of steam as compared with manual power was ascertained in the use of some hand derricks which the authors altered to work by steam power, when one crane so altered did as much work as six hand cranes with four men to each. The cost of working the steam crane did not exceed 12*s.* per day; the total cost of the alterations was therefore cleared in a few weeks, to say nothing of the immense advantage in the saving of time which is obtained. The radius given in the subjoined table is that generally found useful for each size, but it can be modified to almost any extent desired.

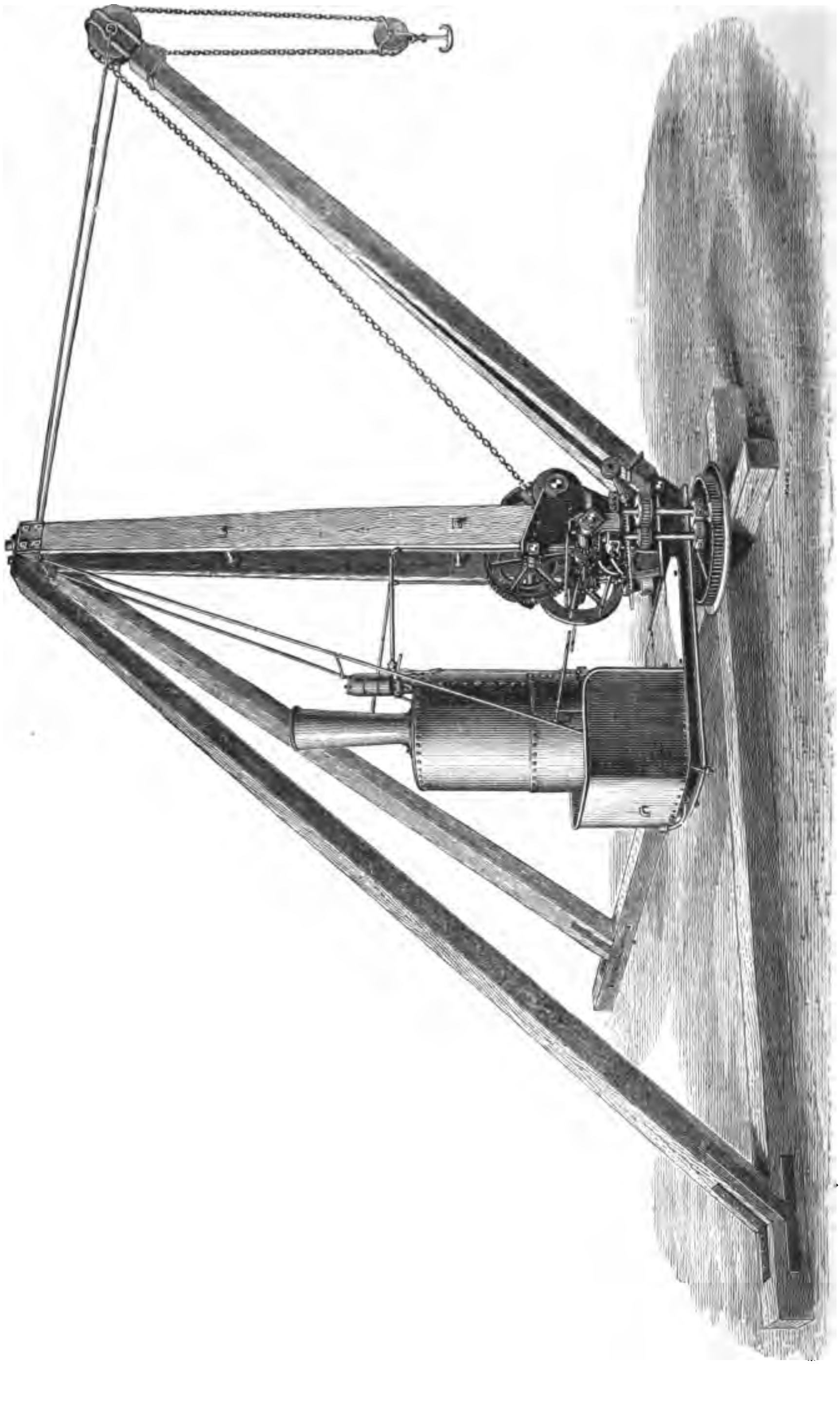


Fig. 111.

Power of crane	1½ ton	2 tons	2½ tons	3 tons	3 tons
Maximum radius	35 ft.	25 ft.	35 ft.	25 ft.	35 ft.
Number of cylinders, diameter, and stroke	1, 6×10 in.	1, 7×10 in.	1, 7×10 in.	1, 7×10 in.	1, 7×10 in.
Price with fixed jib	£190 0 0	£190 0 0	£235 0 0	£235 0 0	£300 0 0
„ derrick jib	£200 0 0	£200 0 0	£250 0 0	£250 0 0	£330 0 0
Price extra with slewing motion	..	..	£25 0 0	£25 0 0	£30 0 0
Price extra with boiler and tank	£70 0 0	£75 0 0	£75 0 0	£75 0 0	£75 0 0
Price extra for iron housing	£15 0 0	£15 0 0	£18 0 0	£18 0 0	£18 0 0
Approximate weight	4 tons	4 tons	5 tons	5 tons	6 tons
„ measurement	300 cub. ft.	300 cub. ft.	400 cub. ft.	400 cub. ft.	500 cub. ft.

Power of crane	4 tons	5 tons	6 tons	8 tons	10 tons
Maximum radius	30 ft.	25 ft.	35 ft.	30 ft.	25 ft.
Number of cylinders, diameter, and stroke	1, 7×10 in.	2, 6×10 in.	2, 6½×10 in.	2, 6½×10 in.	2, 7½×10 in.
Price with fixed jib	£300 0 0	£350 0 0	£450 0 0	£450 0 0	£540 0 0
„ derrick jib	£330 0 0	£390 0 0	£490 0 0	£490 0 0	£590 0 0
Price extra with slewing gear	£30 0 0	£30 0 0	£35 0 0	£35 0 0	£40 0 0
Price extra with boiler and water tank	£75 0 0	£80 0 0	£80 0 0	£80 0 0	£80 0 0
Price extra with iron housing	£18 0 0	£20 0 0	£20 0 0	£25 0 0	£25 0 0
Approximate weight	6 tons	7 tons	7 tons	9 tons	12 tons
„ measurement	500 cub. ft.	500 cub. ft.	600 cub. ft.	700 cub. ft.	800 cub. ft.

Chains to reach to ground line are included in these prices. The cost of packing for shipment is 3 per cent.

Hand derricks, see pages 52 to 54.

The engraving, Fig. 110, is from a photograph of a 3-ton steam derrick without boiler which was used in the construction of the Calcutta Waterworks.

Several of the 8-ton derricks, Fig. 111, were used in the construction of the harbour works at Fiume. Each of these had a fixed double jib, and was fitted with a steam boiler and slewing gear for turning the crane.

FLOATING DERRICKS, Fig. 112. The use of these cranes has extended so much during the last few years that most dock companies now have one or more for transferring heavy packages of machinery, &c. from barges or railway trucks, and putting them on board vessels alongside the quays or jetties in the docks or streams. They are also used for lifting and depositing the heavy concrete blocks employed in the construction of breakwaters or for unloading heavy goods at foreign ports which do not possess harbour or dock accommodation. The floating derrick can be constructed of any power, but that most generally useful will deal with loads up to 20 tons, and reach 20 ft. *clear* of hull, with a clear height of not less than 60 ft. from deck to underside of boom.

These were the dimensions of one designed by the Authors for the East and West India Docks, the hull being of iron and rectangular, 70 ft. long × 32 ft. beam, with a tower above deck of wrought iron, the varying loads being always counterbalanced, thus keeping the craft on an even keel. Water ballast had hitherto been used as a counterweight to the load, but apart from the loss of time and the cost of filling the ballast tanks, the water ballast causes the vessel or hull to heel over to a considerable extent in the opposite direction before the load can be lifted, and does not then act uniformly whilst the boom is being turned round; furthermore, it can only be turned through a limited part of a circle with safety. These objections are, however, entirely overcome by the use of the self-acting counterbalance adopted in the design above referred to, which is an essential feature in this design, because the counterpoise is always in proper relation with the load whatever may be the position of the boom.

The boom or jib can be turned completely round and round like an ordinary pillar crane, and as it only projects over the side carrying the load, the derrick will lay between two vessels and load into either without fouling the yards or rigging of the other. The boom also has a racking in and out motion, to alter the radius from 15 ft. to 35 ft. Two steam-driven capstans, fore and aft of the hull, are provided for warping up to vessels, hauling barges into position, &c.,

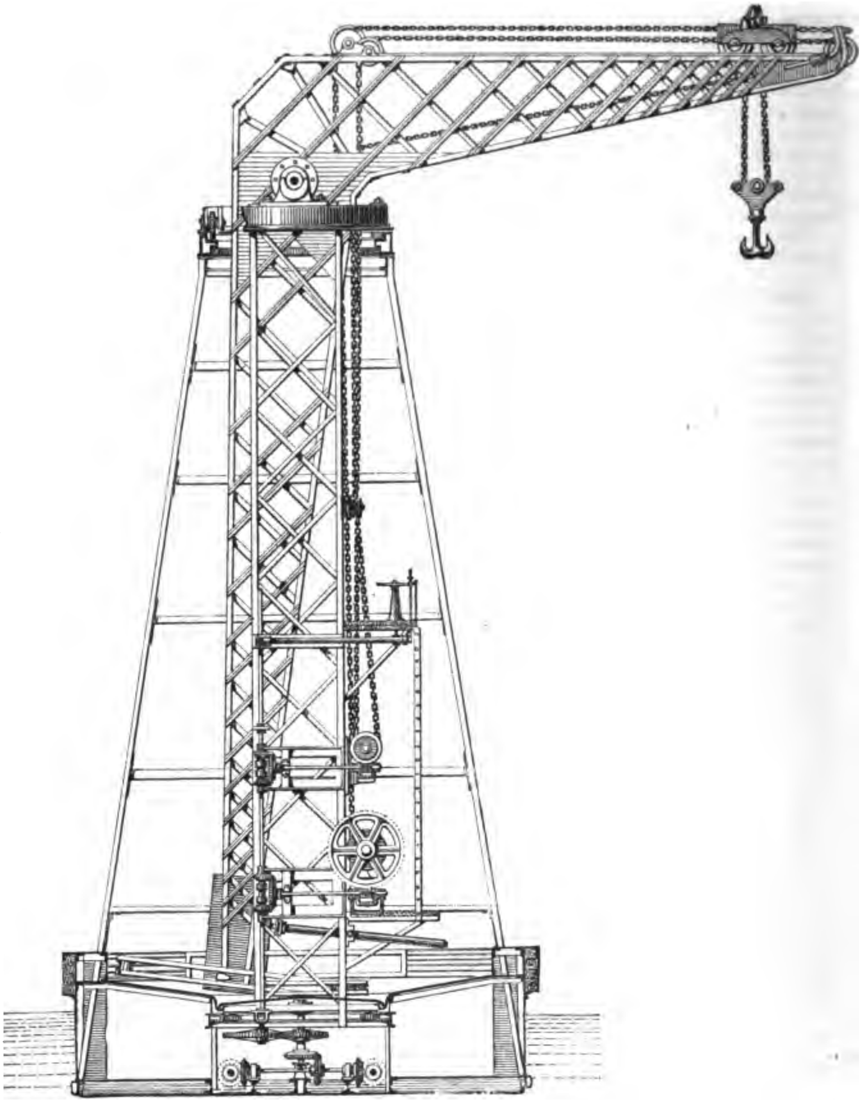


Fig. 112.

and the vessel is self-propelling by means of a pair of twin screws. The engines and boilers are in duplicate, either engine or boiler being sufficient to work the machinery. All the levers are carried up to the platform on the tower, which enables the engineer to obtain a clear view of the hold of a high-sided ship whilst manipulating the whole of the motions.

The hull has two water-tight bulkheads, dividing the vessel into three compartments: one being devoted to the boilers, the centre one to the engines and machinery, and the third gives accommodation for crew and stores.

The cost of such a derrick complete is about £7000. For foreign ports the hull is only partially rivetted up, and shipped in sections, or the hull could in many cases be fitted for the voyage out, and the tower, &c. erected at its destination. The foregoing description is only

intended as an indication of what in practice is found useful, machinery of this character being almost always made to special designs.

A less costly construction of floating derrick, but one frequently used, consists of a strongly-built hull with a pair of fixed shear legs overhanging the stem and tied back to the stern. The load is partially counterbalanced by water ballast pumped into and out of tanks provided to receive it. If the vessel is fitted with engine power, it is brought into position by twin screws driven by the same engines as are used for giving the lifting motions, or by power capstans on the deck; but in some cases a floating derrick is so rarely required, that all the work can be performed by powerful hand-winches of the type shown in Fig. 213 or 214, and hand-power capstans or a winch similar to Fig. 214 may be driven by a portable engine.

This construction is inexpensive as regards the first cost, but the number of hands required increases the working expenses very considerably.

PORTABLE STEAM CRANES, to work heavy loads up to 15 tons, and at a radius which, to be practically useful, should be from 15 ft. to 25 ft. radius, have been but rarely constructed, owing to the difficulty which has been experienced in obtaining the necessary stability on a narrow gauge of rails. Such cranes can however be constructed to *travel* on the 4-ft. 8½-in. gauge, or even on the metre gauge, but when at work, the base must be increased by cross girders, sliding from the carriage, fastening down or some such expedient. If, however, a crane of this power is not required to run with ordinary rolling stock, the widest gauge possible should be allowed, when it becomes as easy to make a 15-ton or 20-ton portable crane as one for 5 tons on the 4-ft. 8½-in. gauge.

The first cost of these cranes may appear high, but when it is considered that one of them will generally answer the purpose of two or three fixed cranes, which, with the cost of foundation, will amount to a large sum of money, the balance will probably be greatly in favour of the portable steam crane, which can move itself to any point where it is required to work, and be operated by one man, especially when the cost of labour in each case is considered.

The following description will give a general idea of the construction. The crane has a pair of steam cylinders with link reversing motions, and the engine shaft is fitted with three sets of bevel wheels, each set having reversing clutches and levers for putting them into contact.

The first set of wheels and clutches gives motion to the slewing or turning of the jib in either direction; the second set is for driving the travelling wheels of the crane, and the third set for altering the radius of the jib from the minimum to the maximum radius.

The set first named is fitted with friction clutches, and the power is taken by a train of wheels to two large friction rollers, which are placed at the foot of the jib, and travel on a turned path. Both these wheels or rollers are driven and the crane jib is slewed simply by the adhesion of surfaces; this effectually prevents the breakage of the gearing, which would otherwise inevitably result from starting or stopping the jib too suddenly. The slewing gear has two speeds.

The second set has toothed clutches, and transmit the power from the engine shaft to a vertical shaft passing through the centre of the crane post to the centre axles of the crane carriage, the leading and trailing wheels being coupled by horizontal shafts and bevel gear; or, if the crane is on springs, the leading and trailing wheels are coupled by pitch chains or side rods; in either case all wheels are drivers.

The third pair also has toothed clutches, and drives a worm shaft working into a tangent wheel keyed on to a chain barrel, to which are attached the guy chains; these, with the pulley block, take the place of the ordinary tie rods, and sufficient power is obtained for lifting the jib with or without a load.

The lifting gear is single and double purchase, and the chains can be made single, double, or treble to the jib head, thus giving, in conjunction with the gearing, a great variety of powers. All these motions can be worked by hand if desired.

If the crane is for a narrow gauge, the cross girders in the carriage are fitted at their extreme end with jacking screws or small hydraulic jacks, and when a load is lifted, a packing of timber is placed under the jacks, thus relieving the road from undue strain, and increasing the base and stability of the crane.

The **10-TON LOCOMOTIVE STEAM CRANE,** Fig. 113, is from a photograph of a crane to travel on 4-ft. 8½-in. gauge, built by the Authors for the East and West India Docks, for unloading timber and all kinds of merchandise from large vessels which are a great height above quay level when light.

The crane does not vary greatly from that last described, excepting that the axles are left long enough to take a set of outside wheels with plain surfaces or flanged wheels for the purpose of increasing the wheel base; it also has the sliding cross girders, and a wrought-iron box for carrying counterbalance weight behind the steam boiler.

The carriage and jib are of wrought iron, and the crane is self-propelling, both pairs of wheels being driven. For price see page 21.

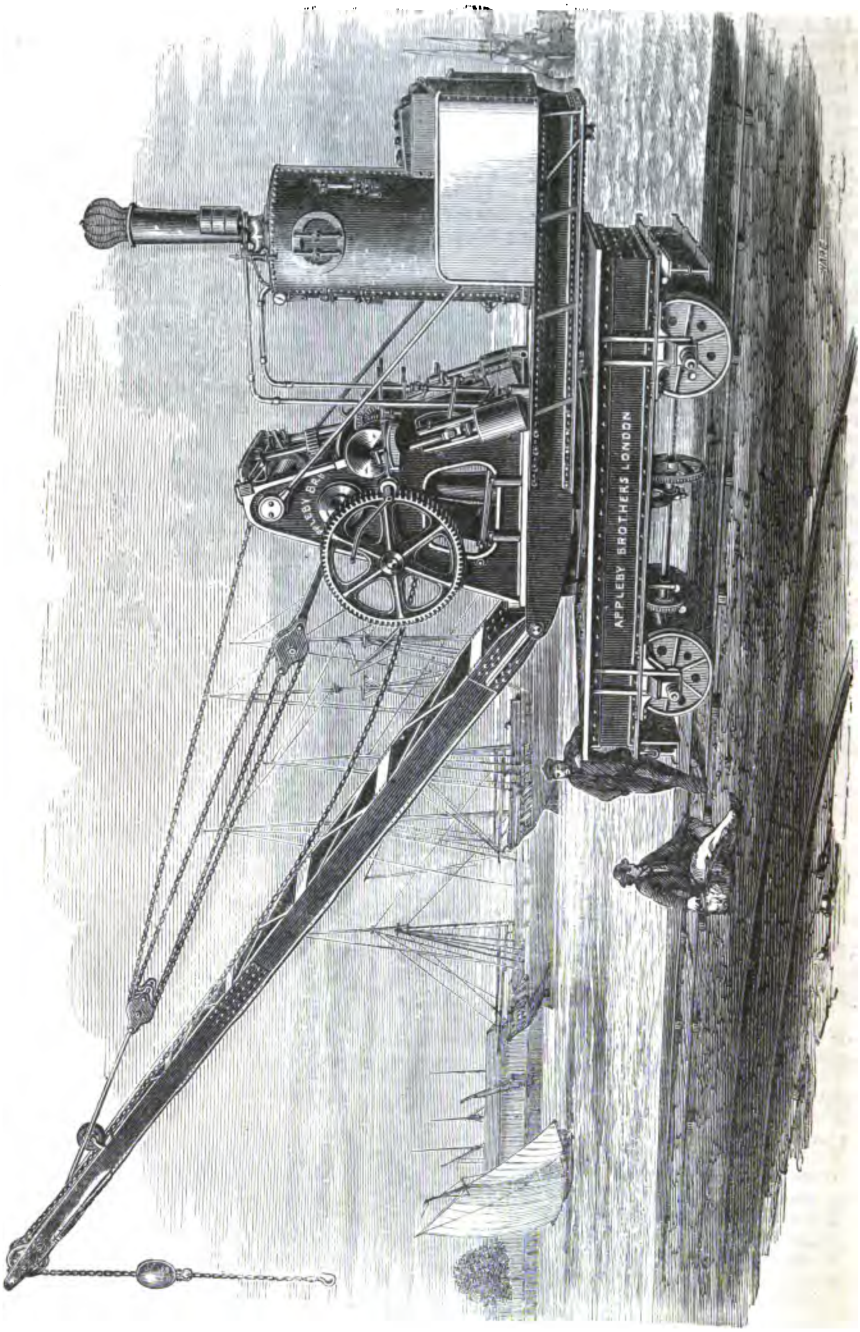


Fig. 113.

The **7-TON STEAM CRANE**, Fig. 114, is the type so largely used in all parts of the world, and selected by the commissioners for the international exhibitions in London, Paris, Vienna, and Philadelphia, for unloading the heavy packages, and specially for placing in position and partially erecting the machinery; and the duty for which they were employed has in each case been performed in such a manner as to secure for the Authors medals of the highest class; indeed, their cranes were exclusively used at the Philadelphia Exhibition.

All the cranes of this type, from 3-tons power and upwards, are mounted on strong cast-iron carriages, unless an exceptional gauge is required, involving the use of wrought iron. The maximum radius at which each crane will lift the maximum load is given in the accompanying list, and if a greater radius is required for a given load, a crane of greater power should be used, but lighter loads than are specified in the list may be lifted at an increased radius.

The great advantages derived from the use of steam portable cranes at previous Exhibitions induced the British and Austrian commissioners to request Messrs. APPLEBY BROTHERS, of Southwark, to supply three cranes for service at Vienna, to lift 7, 5, and 3 tons respectively. (See report in *Engineering*, June 20, 1873.) The largest of these is illustrated by the double-page engraving (pages 22 and 23). Some important improvements have been introduced since this crane was made, but the general appearance and proportions remain the same. The carriage is cast in one piece, the horns being provided with bearings for travelling wheels, and bosses for rail clips, and there is a turned roller path in centre of carriage. All motions, namely, lifting, turning, altering radius, and travelling, are taken from a pair of direct-acting steam cylinders placed slightly at an incline, one outside each side frame. The crank pins are fitted into balanced disc plates; each cylinder has link reversing gear, and the piston rods are guided by blocks working in bored guides cast to the cylinder covers. The post is of wrought iron turned to fit the revolving bed which carries the side frames. The feed-water tank and vertical boiler are carried from the revolving bed, and are placed at such a distance behind the post as to form some counterbalance to the load to be lifted. The lifting power is conveyed from the crank shaft to the chain-barrel by means of spur gear, and the load may be lowered by reversing the engines, or by the brake. The turning motion is obtained through double friction clutches, and the crane may be moved in either direction simultaneously with any other operation; this motion being performed by driving the friction roller under the jib instead of through toothed gear on the carriage, the risk of breakage is greatly reduced. The derrick motion is obtained by a worm and tangent-wheel on the chain-barrel, the worm locking the jib in any position. The travelling motion is conveyed from the crank shaft to both axles by a train of spur and bevil gearing, one shaft passing down the centre of post. The working expenses for these cranes in London are about 12*s.* a day, the average daily work of a 3-ton crane being 300 tons lifted 30 feet and deposited in trucks.

PRICES OF PORTABLE STEAM CRANES, Figs. 113, 114, and 115.

Power of crane	3 tons	5 tons	7 tons	10 tons
Maximum radius with full load ..	14 ft.	14 ft.	15 ft.	16 ft.
Number of steam cylinders, diameter, and stroke	2, 6½ × 10 in.	2, 6½ × 10 in.	2, 7½ × 10 in.	2, 7½ × 10 in.
Price of crane to lift and turn with fixed jib	£400 0 0	£500 0 0	£600 0 0	£800 0 0
Price of crane to lift, turn, and alter radius of jib, all by steam ..	£425 0 0	£530 0 0	£635 0 9	£850 0 0
Price of crane to lift, turn, and alter radius of jib, all by steam, and travel	£450 0 0	£560 0 0	£680 0 0	£900 0 0
Price extra for wrought-iron jib ..	£8 0 0	£15 0 0	£20 0 0	£25 0 0
Price extra for set of rail clips ..	£5 0 0	£6 0 0	£7 0 0	£10 0 0
Price extra for felting, lagging, and casing boiler	£15 0 0	£18 0 0	£20 0 0	£20 0 0
Price extra for galvanised house ..	£20 0 0	£25 0 0	£28 0 0	£32 0 0
Price extra for cross girders to increase base	£10 0 0	£15 0 0	£20 0 0	£25 0 0
Price extra for steam donkey pump and fittings	£13 0 0	£13 0 0	£15 0 0	£15 0 0
Price extra for injector and fittings	£8 0 0	£8 0 0	£10 0 0	£10 0 0
Price extra for stoking tools and fitter's tools	£4 0 0	£4 0 0	£4 0 0	£5 0 0
Approximate weight	10¼ tons	13¾ tons	16¼ tons	20 tons
" measurement ..	500 cub. ft.	580 cub. ft.	700 cub. ft.	900 cub. ft.

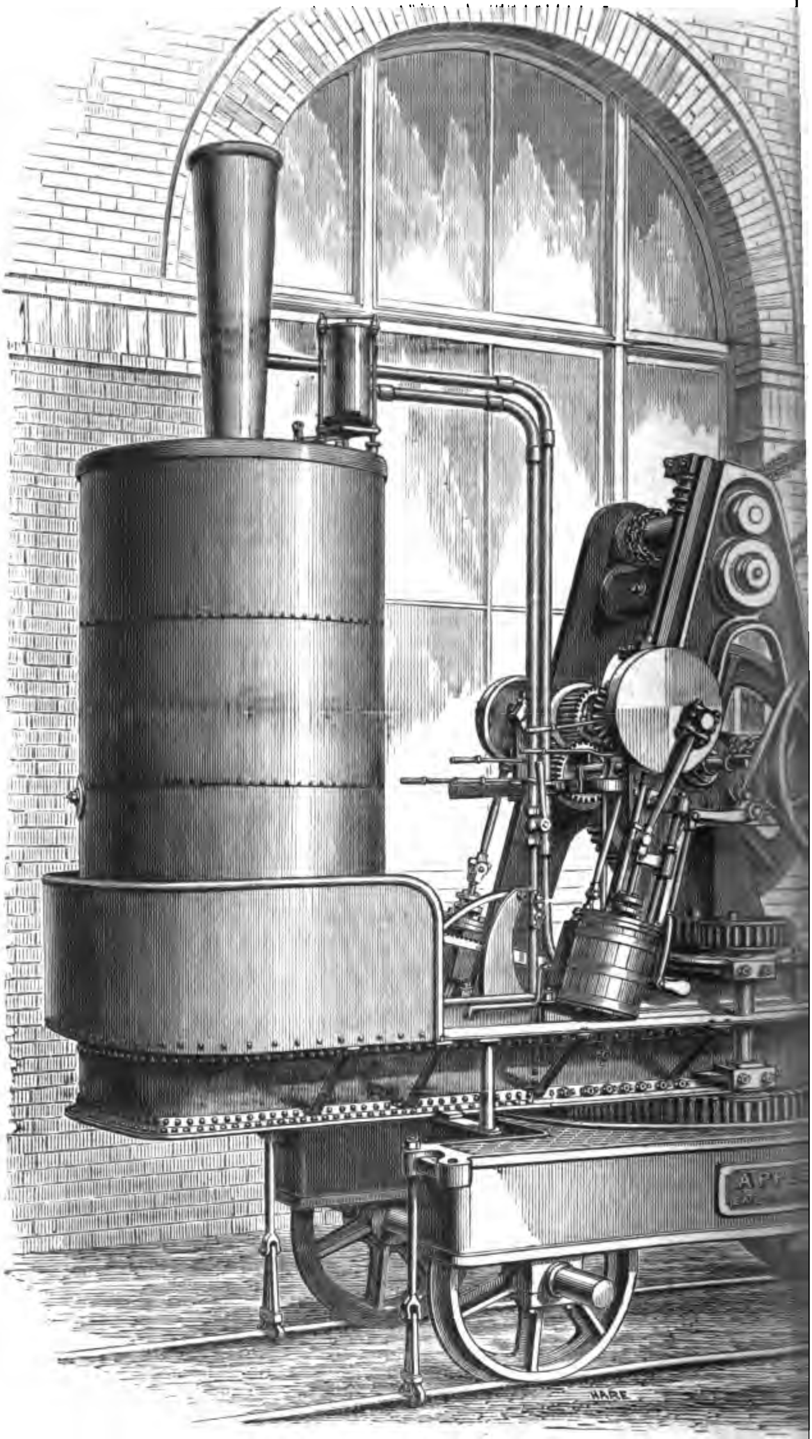
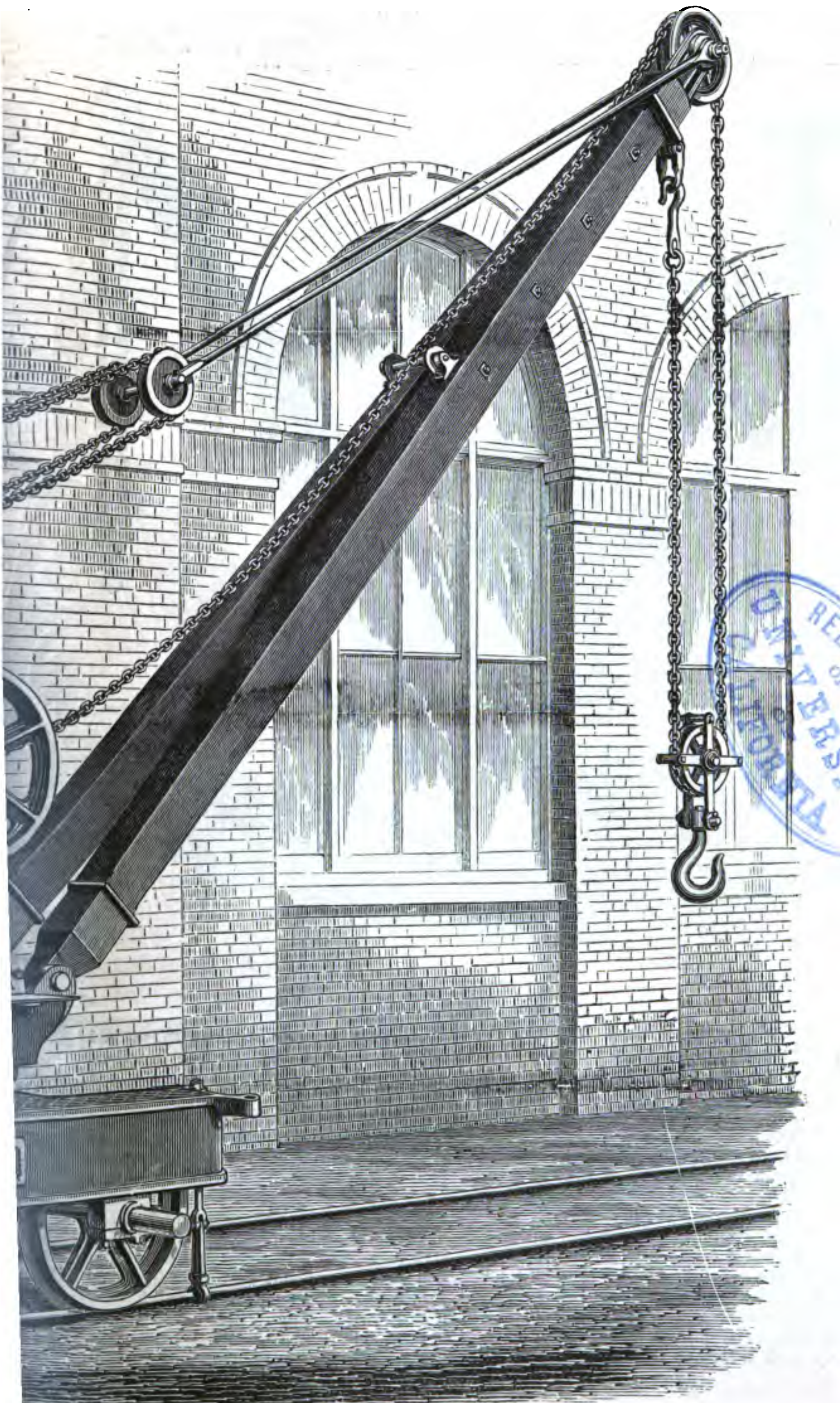


Fig. 114.



(For description and prices, see page 21.)

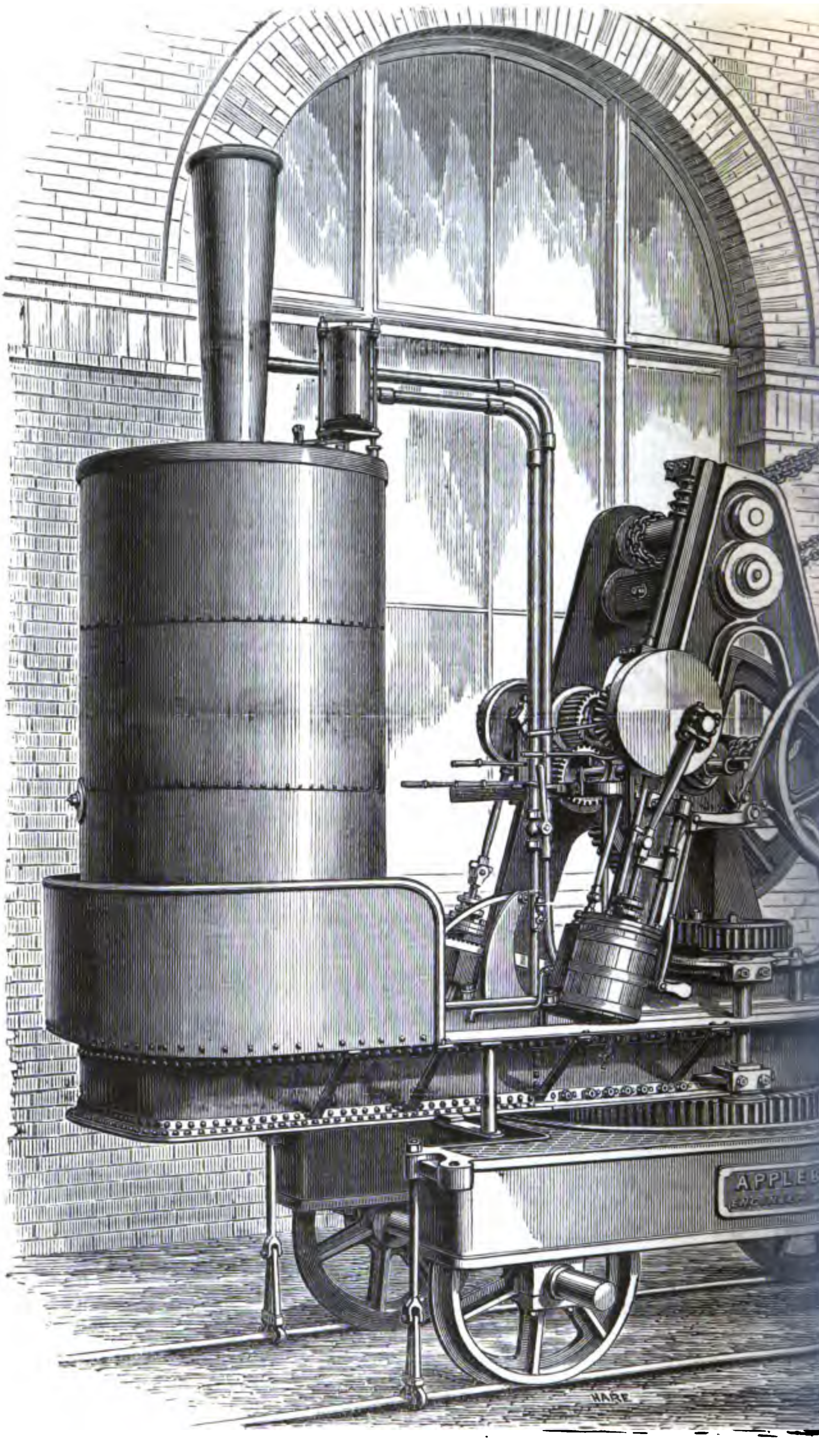
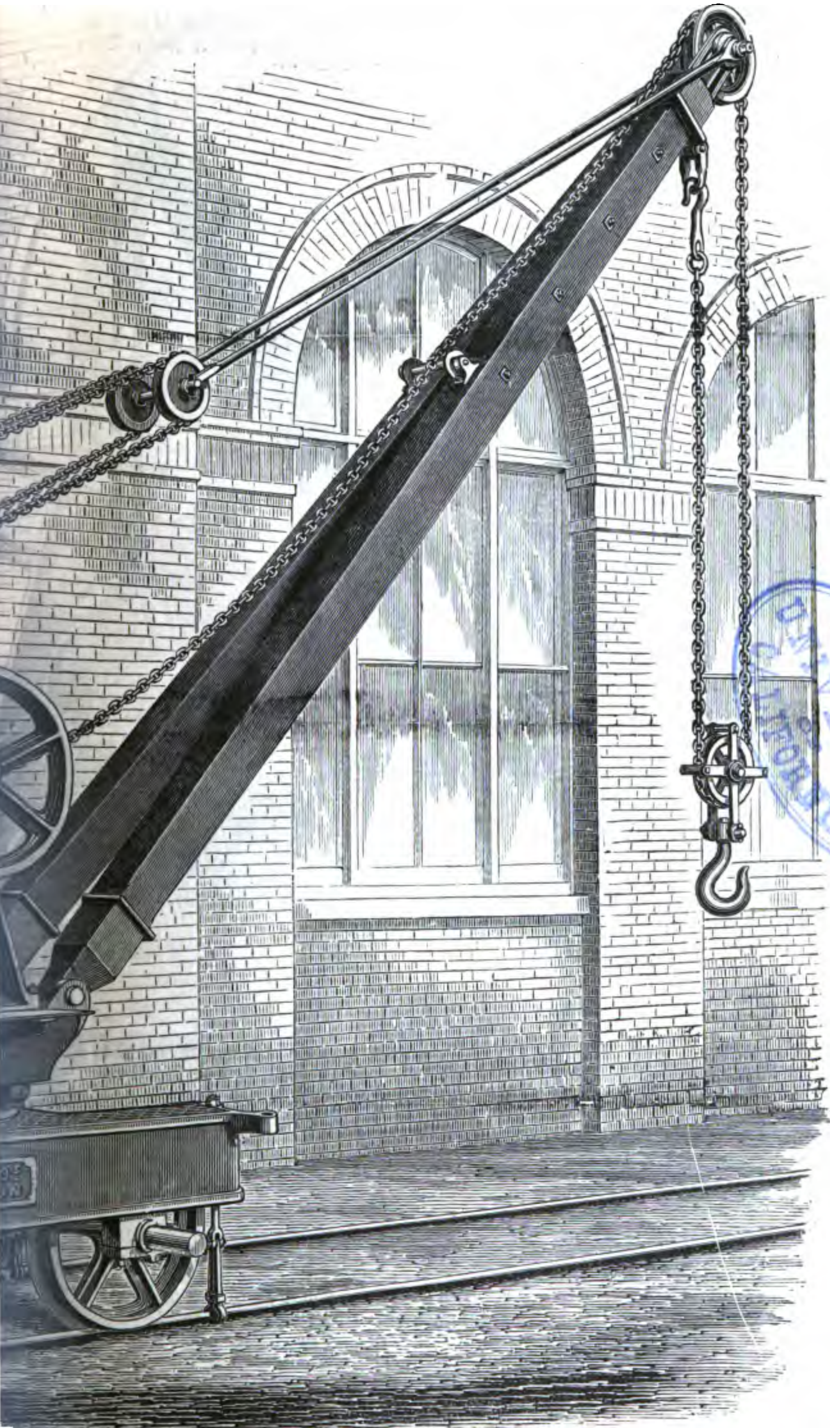


Fig. 114.



(*For description and prices, see page* 21.)

The **3-TON CRANE**, Fig. 115 (No. 41), is of exactly the same design as Fig. 114, the proportions only being different; this crane was not fitted with self-propelling gear, but the foregoing description will apply generally to it. For price see page 21.

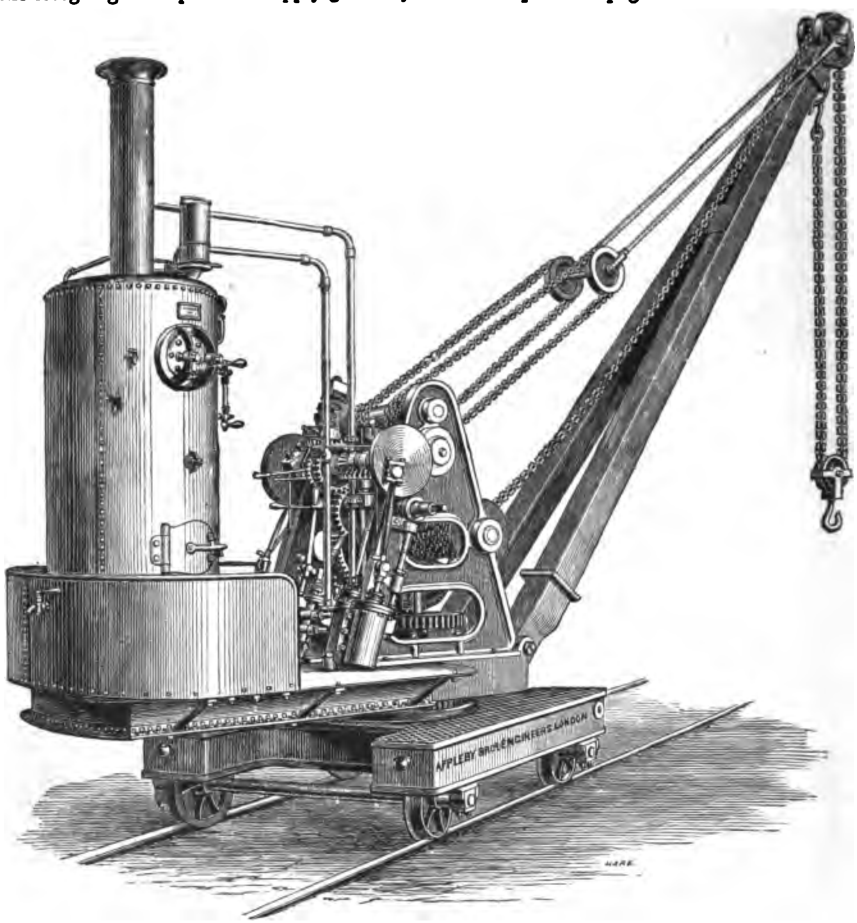


Fig. 115.

The **5-TON PORTABLE STEAM CRANE**, Fig. 116, differs materially from those last referred to, and was designed with a view of producing a crane to perform the two functions most required, those of lifting and turning, at the lowest cost consistent with strength and thorough efficiency; these conditions have been obtained most completely, and cranes of this construction are especially suitable for contractors' use or for any work which does not require a variable radius of jib or steam travelling motions. A reference to the prices of these, and of the type, Fig. 114, shows a wide difference in cost, but apart from this, for some kinds of work there is an advantage in the centre of gravity being kept low, and in having nothing to impede the view of the driver when working.

The 5-ton crane has two steam cylinders placed horizontally on the bed plate, and is fitted with case-hardened link reversing motions; the lifting gear is single purchase, the double chain and block being used only when lifting the maximum load. The first motion of the slewing gear is given by double friction clutches, so that the crane may be turned in either direction simultaneously with lifting or lowering; and the power is transmitted by suitable gear to the two friction wheels at the foot of the jib. Both of these wheels being driven, not only is much greater adhesion obtained, but also the wear and tear of the friction wheels and the path on which they work is far less than in cranes of similar power in which only one wheel is used.

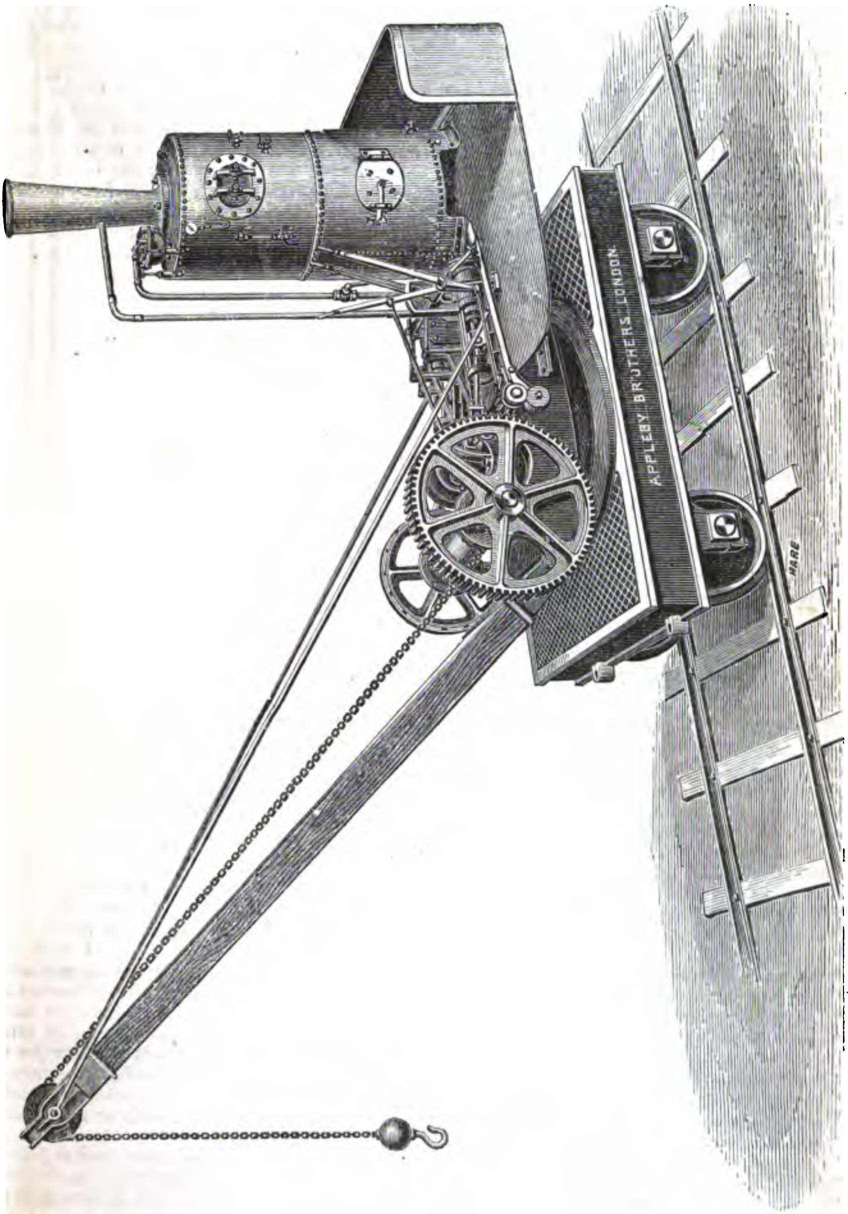


Fig. 116.

The levers for working the several motions are brought together as shown, and as they all move in one direction, the crane is very handy and easy to work. It will be observed that the ordinary crane post is dispensed with, and is replaced by a central wrought-iron pin with a solid head, which works on loose washers surrounded by an oil chamber. The lower end of the pin is firmly cottered into the crane carriage, so that the strain on the pin is tensile, a principle which has been successfully adopted in the construction of cranes of the heaviest kind—up to 50-tons load, at 35 feet radius. The boiler is fixed on a feed-water tank, and is set back as far as practicable from the centre of the crane, and forms a useful counterpoise to the load; the feed pump is worked from the cross head of one of the engines, and the boiler is supplied with all necessary furnace and steam mountings, including double safety valves, and Bourdon's or other approved steam pressure gauge. The crane carriage for all powers is in one massive casting; the smaller sizes have only one roller under the jib, and usually only one cylinder, but they are made with double cylinders at an extra cost of from £15 to £20; this is done by fixing a cylinder at a right angle with the horizontal cylinder, the pistons being coupled to the same crank pin, one set of eccentric sheaves and straps serving for both link motions. This arrangement is adopted when it is considered essential that light cranes should have two cylinders, but experience has amply proved that a single cylinder with large ports is easily handled after very little practice, and that there is great advantage in the relatively large wearing surfaces of the single cylinder as compared with those of two smaller cylinders. Probably the total economy will be in favour of the single cylinder for small cranes, the main question being rather low cost of maintenance than some possible saving in consumption of fuel.

PRICES OF PORTABLE STEAM CRANES, Fig. 116.

Power of crane	1½ ton	3 tons	4 tons	5 tons
Maximum radius with maximum load	12 ft.	14 ft.	14 ft.	14 ft.
Number of cylinders, diameter, and stroke	1, 7×10 in.	1, 7½×10 in.	1, 8×10 in.	2, 7×10 in.
Price of crane to lift and slew ..	£250 0 0	£300 0 0	£350 0 0	£425 0 0
Price extra if with two cylinders ..	£15 0 0	£18 0 0	£20 0 0	—
Approximate weight	6 tons	7 tons	9 tons	11 tons
" measurement ..	300 cub. ft.	400 cub. ft.	450 cub. ft.	500 cub. ft.

For prices of housings, &c., for cranes, see page 21.

LOCOMOTIVE STEAM CRANES ON PERMANENT-WAY CARRIAGES, Fig. 117. The superstructure is the same as is described and illustrated, Fig. 114. The carriages are, however, of different design, and are constructed to run at high speeds with ordinary rolling stock, as required more especially by railway companies. The use of these cranes is now becoming very general, and they are rapidly superseding the hand cranes hitherto employed for special service, or for breakdown work.

The engraving of this crane is reproduced from that which appeared in *Engineering*, September 10, 1875, with the following descriptive matter:—

"The locomotive steam crane, illustrated on the preceding page, and built for the Midland "Railway Company, carries a load of 5 tons. The travelling motion can, however, be thrown "out of gear, and the crane, being securely locked, can be attached to a train for travelling to "any part of the line where its services are required. The cylinders are fitted with link "reversing gear, and the several motions are transmitted from the engine shaft; there are four "speeds of lifting, and the load can be lowered either by the brake or by reversing the engines; "the turning motion is effected through double friction clutches, and suitable gear which "drives a wide roller immediately under the jib, and this operation is performed in either "direction, and simultaneously with any of the others, and being obtained entirely by the "friction of surfaces instead of by toothed gear on the base-plate, the risk of breakage arising "from stopping or starting too suddenly is entirely avoided. The derrick motion for altering "the radius is worked by worm gear and a pair of chains, one end of which is attached to the "crane-frames, the other end coiling round the derrick barrel. The travelling motion is "obtained by a shaft passing through the centre of the crane-post, and driven from the crank-"shaft, the lower end of this vertical shaft giving motion to another shaft fixed horizontally "under the crane-carriage, and in order to allow of the deflection of springs, the power is "transmitted through pitch chains from this shaft to both travelling axles. The crane is "mounted on a wrought-iron carriage similar in all respects to the ordinary permanent-way "stock, and it is used at the company's shops at Derby, or is sent to different parts of the line "where lifting power is required. The jib is curved in order to give sufficient clearance for

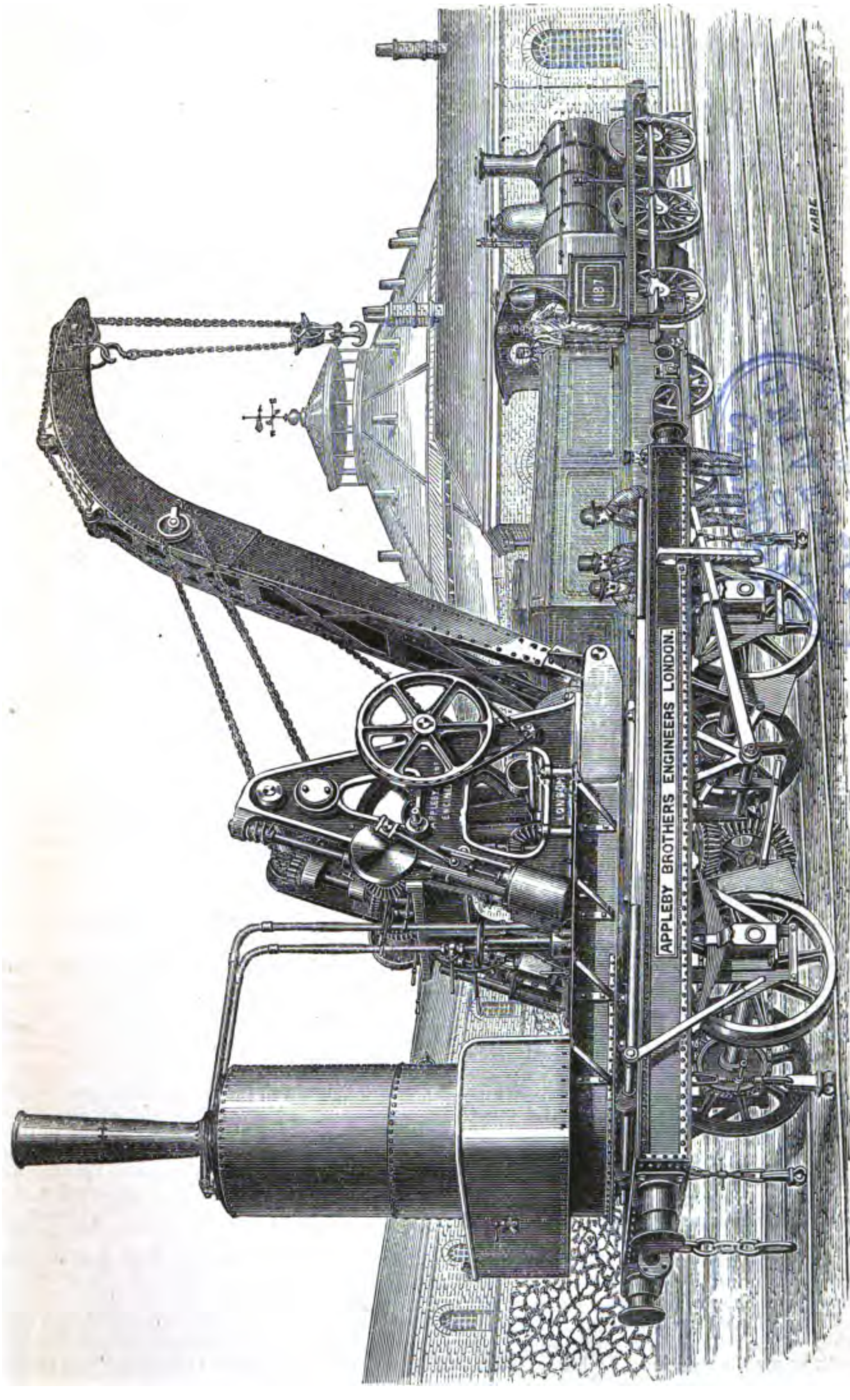


Fig. 117.

"lifting large logs on to trucks, for stacking timber, &c., or even to lift a disabled truck and "place it on a goods wagon. We understand that several cranes of this type have been "delivered to the Midland Railway Company, or are now in course of construction, and it "would certainly appear that great economy, both in time and labour, would be obtained if a "few cranes of this type were used, instead of a far larger number of fixed or permanent-way "hand cranes which are now so generally used, many of them at stations where they are not "employed half a dozen times in a year. In the event of an accident on the line there can be "no question that the rapid working of steam as compared with hand power, would greatly "reduce the time required to clear away *débris*, and possibly might thus mitigate much suffering "caused by accidents to passenger trains."

For prices, &c. of these cranes, see list below.

The crane, Fig. 118, of 3-tons power, was constructed for the Finland States Railways, the variation being only in the jib and the general proportions. A crane of this type was also selected by the commissioners for the Philadelphia Centennial Exhibition for use in the American section.

PRICE LIST OF LOCOMOTIVE PERMANENT-WAY STEAM CRANES, Figs. 117, 118.

Power of crane	3 tons	5 tons	7 tons	10 tons
Number of cylinders, diameter, and stroke	2, 6½ × 10 in.	2, 6½ × 10 in.	2, 7½ × 10 in.	2, 7½ × 10 in.
Maximum radius with full load ..	14 ft.	14 ft.	15 ft.	16 ft.
Price of crane to lift and turn ..	£460 0 0	£610 0 0	£690 0 0	£1000 0 0
Price of crane to lift, turn, and derrick	£485 0 0	£640 0 0	£725 0 0	£1050 0 0
Price of crane to lift, turn, derrick, and travel..	£510 0 0	£670 0 0	£770 0 0	£1100 0 0
Price extra if fitted with handles for hand	£5 0 0	£5 0 0	£10 0 0	£10 0 0
Price extra for set of rail clips ..	£5 0 0	£6 0 0	£7 0 0	£10 0 0
Price extra for felting, lagging, and casing boiler	£15 0 0	£18 0 0	£20 0 0	£20 0 0
Price extra for galvanised iron house	£20 0 0	£25 0 0	£28 0 0	£32 0 0
Price extra for sliding cross girders	£10 0 0	£15 0 0	£20 0 0	£25 0 0
Price extra for straight iron jib ..	£10 0 0	£15 0 0	£18 0 0	£20 0 0
Price extra for curved iron jib ..	£15 0 0	£20 0 0	£30 0 0	£40 0 0
Approximate weight ..	12 tons	15 tons	18 tons	23 tons
" measurement .	600	700	850	1050

The above prices include springs, buffers, draw-springs, couplings, safety chains, wheels and axles of best make, brakes, &c., as shown. The 10-ton crane has a six-wheeled carriage.

The **PORTABLE ENGINE WITH HOISTING GEAR AND CRANE JIB**, Fig. 119 (No. 13), has been designed specially to fulfil the requirements of builders and contractors more completely than an ordinary portable engine. The first cost of these engines is but little in excess of the ordinary portable engine, and they have been used for several years past in the construction of some of the best organised public works in Great Britain and the Colonies.

If it is essential that the motive power should be used for driving machinery continuously, whilst the lifting motion is only used intermittently, as shown in the outline engraving, Figs. 120 and 121, the engine should be fitted with governors, and the lifting motion driven by friction gearing or spur gearing put into motion by a friction clutch.

The advantages of this arrangement have been amply proved on the extensive harbour works carried out under Sir John Coode, C.E., in the Isle of Man, Jersey, South Africa, &c., where engines of this type were used to drive the stone breakers and concrete-mixing apparatus required for making the concrete blocks, and at the same time lift the materials to supply both machines.

In the formation of the Metropolitan and St. John's Wood Railway several of these engines were worked in the centre of the St. John's Wood Road, and although at certain times of the day it is much crowded with carriage traffic, no inconvenience was experienced. The mode of working adopted by Mr. Eagles, who superintended the work on behalf of Messrs. Lucas and Aird, was as follows. The excavation being in open cutting to an average depth of about 30 ft. below the road level, and, as already stated, in the centre of a busy thoroughfare, it was

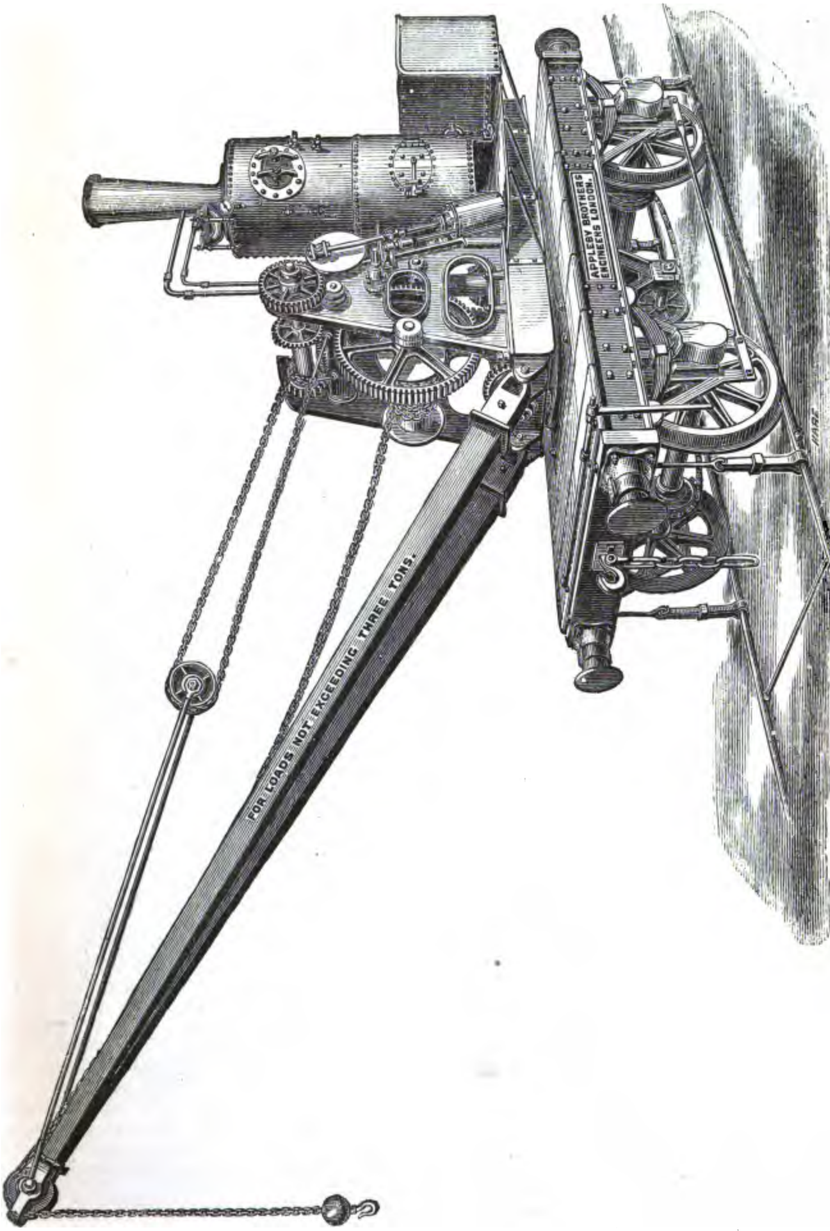

APPLEBY BROTHERS
ENGINEERS LONDON.
FOR LOADS NOT EXCEEDING THREE TONS.

Fig. 118.

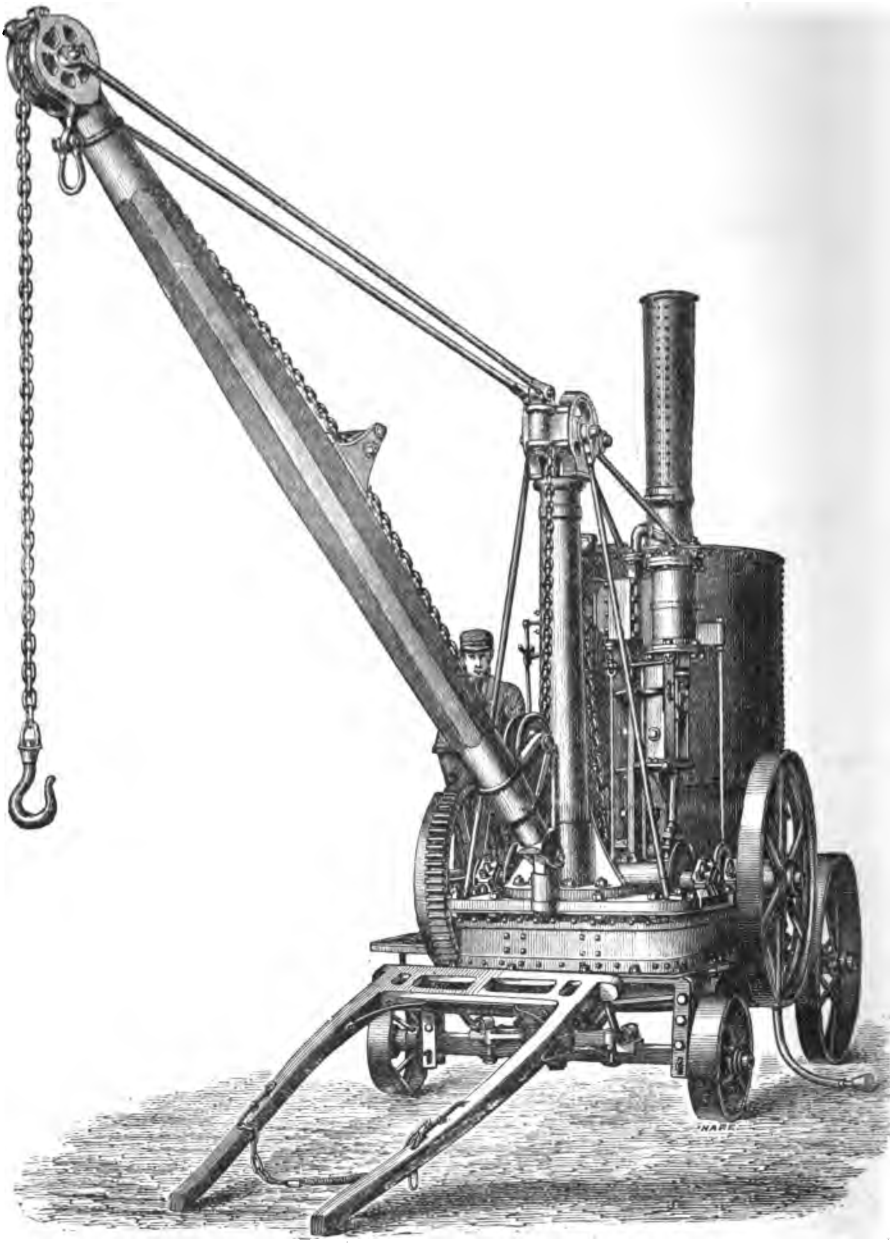


Fig. 119.

necessary to complete the tunnel below and make good the surface as quickly as possible. The work was therefore taken in short lengths, the engine being on a line of rails laid on timbers over the excavation, which was in sand; the sides were timbered, and the timbering was removed for subsequent use, as the work was completed and filled in. The engine and a mortar pan were fixed on a timber frame with wheels to run on the rails over the cutting, and being fitted with frictional gear, it was used for lifting the excavated stuff from the cutting below and tipping it into carts for removal; and at the same time it was driving the mortar pan continuously, which prepared the mortar required in the construction of the brickwork of the tunnel.

The total working expense of the engine whilst performing the work above described, including fuel, wages, oil, &c., amounted to 17*s.* 5*d.* per day, or, including depreciation and interest on plant, about £1 per day.

The following data have been kindly supplied by Mr. Maxwell, C.E., under whose superintendence the River Medlock Improvements were carried out in 1868 and 1869. The duty performed by one of these cranes with spur gear was 565 tons lifted 33 feet high, in turnover skips, and discharged into carts, in a day of ten hours, the total working expenses being, for fuel, wages, oil, &c., depreciation, and interest on plant, 13*s.* per day, or equal to about one-third of a penny per ton lifted 33 feet high.

When fitted with broad wheels, locking fore-carriage and shafts, as shown in Fig. 119, these engines are as easily moved from place to place as an ordinary portable engine, and an arrangement is provided for securely locking the front axles rigidly to the frame whilst the engine is at work; if required, they are made with small plain wheels at each end, without locking plate, &c., or with single or double flanged wheels, for 4-ft. 8½-in. or other gauge.

The jib will describe about three-fourths of a circle, and pulls round very lightly by hand, the man stationed to tip the buckets and do the trimming in the carts pulling it round by a rope to the jib head. The starting valve, clutch levers, foot brake, feed pump, &c. are all brought together, so that one man can easily work the crane.

The frame is of wrought iron; the pedestals have gun-metal bearings, and the fly-wheel is made wide on the face and turned so as to be available for driving any kind of machinery by a strap, and the shaft is long enough to take an extra pulley.

Each crane is provided with a chain of suitable length to reach 20 feet below ground-line. The end of the chain barrel shaft is left long enough to take a pumping arm for working pumps, &c., and they have been fitted with large drums for wire rope inside or outside the framing.

The engraving, Fig. 123 (No. 15), shows a crane of the same type, but of 3 horse-power, and to lift 5-cwt. loads at high speed.

HOISTING ENGINES, Figs. 119 and 122.

	SINGLE CYLINDER.					DOUBLE CYLINDER.		
Nominal Horse Power .. tons	3	4	6	8	12	6	8	12
Diameter of Cylinder	5½″	6½″	7¼″	9″	11″	5½″	6½″	7¼
Price, without wheels and axles (for fixing on brick or timber)	180	218	249	282	352	275	343	397
Price, with plain or flanged wheels for tram or rails (without shafts and locking-plate)	185	223	255	289	360	281	350	405
Price, with road-wheels, shafts, and locking-plate	190	228	260	295	370	286	355	415
Extra for governors and expansion-valve	10	12	13	20	25	15	20	25
Extra for link-motion reversing gear	7	8	10	11	12	15	18	20
Extra if fitted with frictional gear	5	7	9	11	13	9	11	13
Extra for felting, lagging, and covering boiler with sheet-iron	10	12	13	15	16	13	15	17
Extra for skeleton roof	8	9	10	10	10	10	10	10
Extra for packing for shipment..	6	7	8	9	10	8	9	10
Approximate weight .. Tons	3½	4½	5	7½	8½	4	7½	8½
„ measurement .. Cub. ft.	200	270	380	450	550	350	450	550

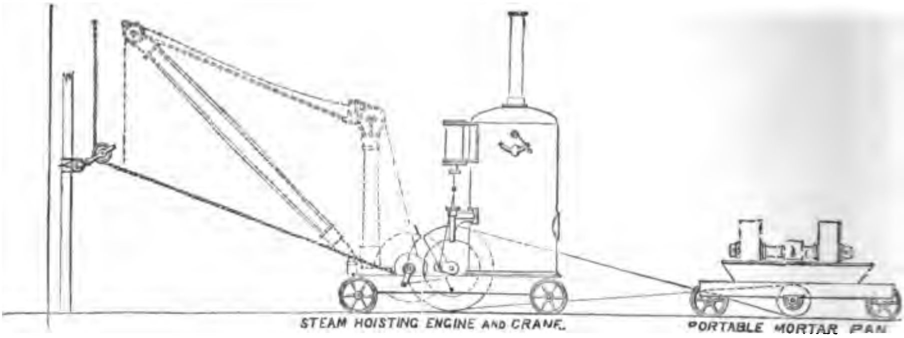


Fig. 120

Elevation of Fig. 119 (No. 13), portable engine with crane, fitted with frictional gear for driving a mortar pan at the same time as hoisting.

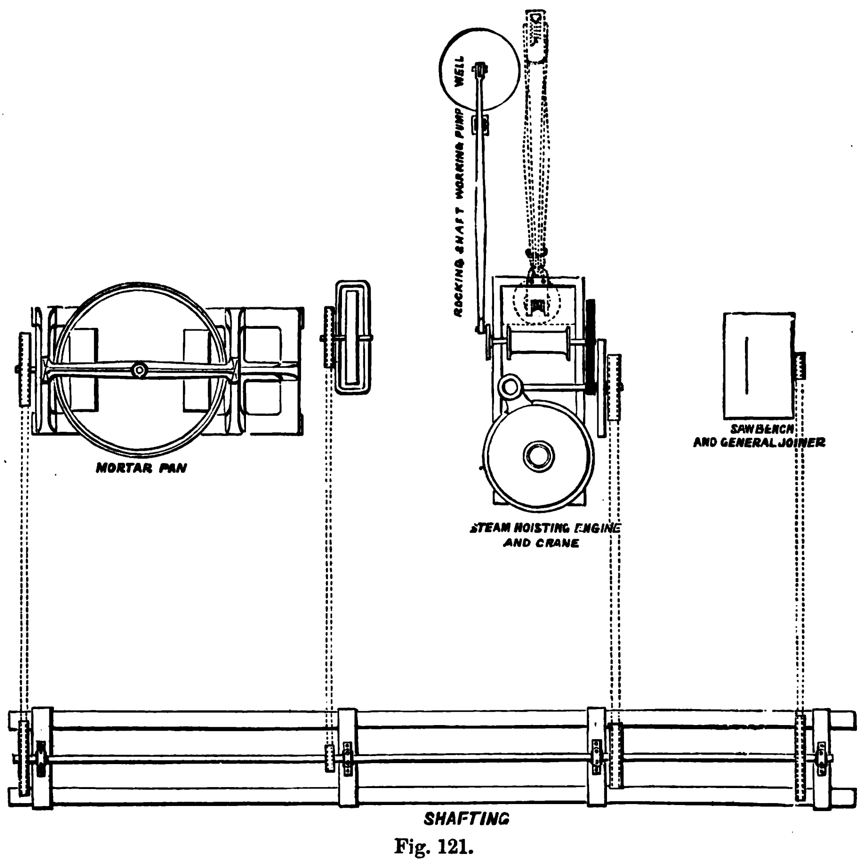


Fig. 121.

Plan showing an engine of the type, Fig. 119 (No. 13), working a small plant of builder's machinery by a line of shaft fixed on a couple of timbers, and driving a mortar mill, saw bench, grindstone, and pumps. The engine can at the same time be made available for hoisting materials on the building in course of erection, as shown in Fig. 120. For price, see page 31.

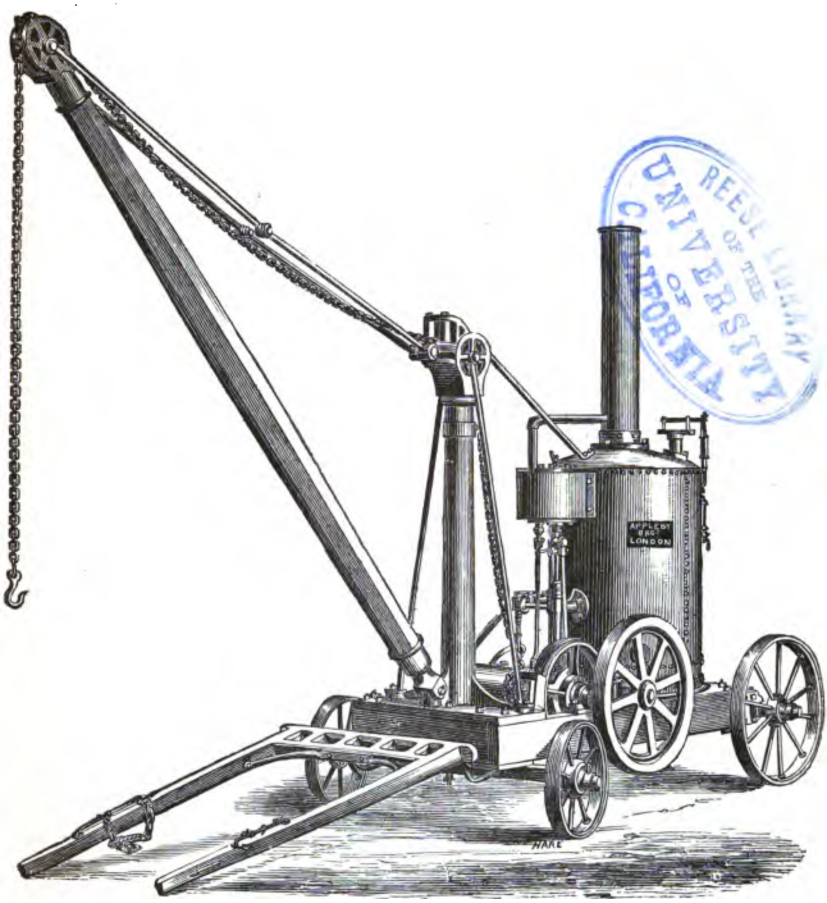


Fig. 122.

HYDRAULIC CRANES. The use of hydraulic power for working cranes, hoists, engines as motors for capstans, opening and closing dock gates, swinging bridges, &c., is so general, and so well understood by engineers, that it will be unnecessary to describe the system in detail; the following brief description may, however, enable the non-practical reader to form an opinion whether it is adapted for any special object he may have in view, whether for docks, railway depots, warehouses, or establishments of a similar character.

Assuming that it has been decided to adopt the hydraulic system, it is desirable, but not essential, that the buildings to contain the engines, boilers, and accumulators, should be as central as possible, and these should all be proportioned to the present *and prospective* magnitude of the works, or space should at all events be allowed for the probable duplication of plant.

The boilers are usually of the Cornish type, and each of the engines is fitted with a double-acting hydraulic pump coupled directly to the end of the piston-rod, and each pump forces the water into an accumulator.

The accumulator is a vertical cylinder, which is proportioned in diameter and height to the number and power of the cranes or other machines to be employed. This cylinder is fitted with a leather collar or gland, through which works a ram or plunger with a massive crosshead on the upper end, to which is attached an annular weight case surrounding and sliding over the above-named cylinder. The weight case is filled with ballast until the total weight on the ram is equal to (usually) 700 lbs. per square inch; water is then forced into the cylinder or accu-

mulator by the hydraulic pumps, until the ram, loaded as above described, reaches the top of the accumulator. At this moment a self-acting arrangement arrests the motion of the engines, but immediately the ram begins to descend, in consequence of some of the stored power having been used, the engines and pumps are set in motion automatically, and the ram is again lifted.

It will be clear that the water contained in the cylinder (so long as the weight case is sustained by the ram) will be under the pressure due to the area of the ram and the load on it, and that all the mains taken from this cylinder or accumulator will likewise be under the same pressure (assumed at 700 lbs. per square inch); the mains and branches may be taken to almost any distance, with no loss excepting that due to friction, and as the quantity to be passed is small, if the mains are a reasonable size, this amounts to very little; if, however, the mains are carried to a great distance, an accumulator should be placed at both ends of the works (the mains are frequently carried three to four miles), and small branches are taken from the main pipes to supply cranes, hoists, hydraulic engines, &c. at any point where power is required.

It will be well to bear in mind that, as the cylinder must be filled every time it is used, exactly the same power is expended in lifting the empty chain as is required to raise the maximum load the same height, and that true economy will be obtained by adopting the treble ram, or some similar expedient, for all loads above 10 cwt.; the first cost is of course somewhat greater than if the single ram is used, but it will be amply repaid in the lower working expenses due to the lower consumption of power.

Engravings and descriptions of a few of the cranes used in connection with this system are given in the following pages, and instances will be referred to where a natural head of water has been used with great advantage and economy.

HYDRAULIC FIXED WHARF or PILLAR CRANE. The 20-ton crane, Fig. 123, embodies many improvements, and gives a general idea of the construction adopted for all sizes and for all sweeps. The chief improvement is that the crane is entirely self-contained, the whole of the machinery being carried within the crane structure, obviating the necessity of costly foundation pits close to the crane, and saving the immense ground space occupied by cranes of the old construction, in which the cost of foundations is often equal to the cost of the crane and that of the whole of the machinery; the valve gear being on the crane also simplifies the construction.

The crane is fitted with three lifting cylinders, giving three lifting powers, for 7, 14, and 20 tons; for the lowest power only the centre cylinder is used; for the second power, the two outer cylinders without the centre one; and for the full power all three cylinders are used. Another advantage in this design of crane is that, the cylinders being vertical, the use of a cylinder to overhaul the lifting cylinder is avoided, and a much lighter ball can be used on the lifting chain; the slewing cylinder is double-acting, and will slew the jib a complete revolution.

The crane jib is constructed chiefly of wrought iron, and can either be raised on a wrought-iron pedestal, as shown, when a great length under the jib-head is desired, or sunk in a pit of masonry.

Hydraulic power can be fitted to the Fairbairn cranes, Fig. 101.

Hydraulic hoists and lifts, see pages 96 to 99.

Hydraulic engines, see Section 1, pages 52 to 54.

PRICE LIST OF HYDRAULIC WHARF OR PILLAR CRANES, Fig. 123.

Power of crane	3 tons	5 tons	10 tons	15 tons	20 tons
Radius of jib	14 ft.	16 ft.	18 ft.	20 ft.	25 ft.
Number of powers.. ..	Single	Single	Double	Double	Treble
Price of crane exclusive of pedestal foundation ..	£300	£500	£750	£1000	£1500
Approximate weight ..	5 tons	9 tons	18 tons	25 tons	30 tons
,, measurement	700 cub. ft.	1000 cub. ft.	1500 cub. ft.	1800 cub. ft.	2000 cub. ft.

The measurements are given supposing the cranes to be rivetted up; for shipment they may be sent in sections, and thus reduce the measurements.

Cranes of a similar type, and made very light, are much used for discharging coals, &c. from ships and steamers. These are fitted with a simple apparatus for weighing the coal lifted, the talley being kept by the crane man, or by the man tipping the buckets, but if the weighing-in is not required, the crane can be fitted with self-discharging buckets. The buckets or skips for discharging coal usually contain half a ton, that being found in practice the best size to use in the hold. For illustrations of skips, see Section 5.

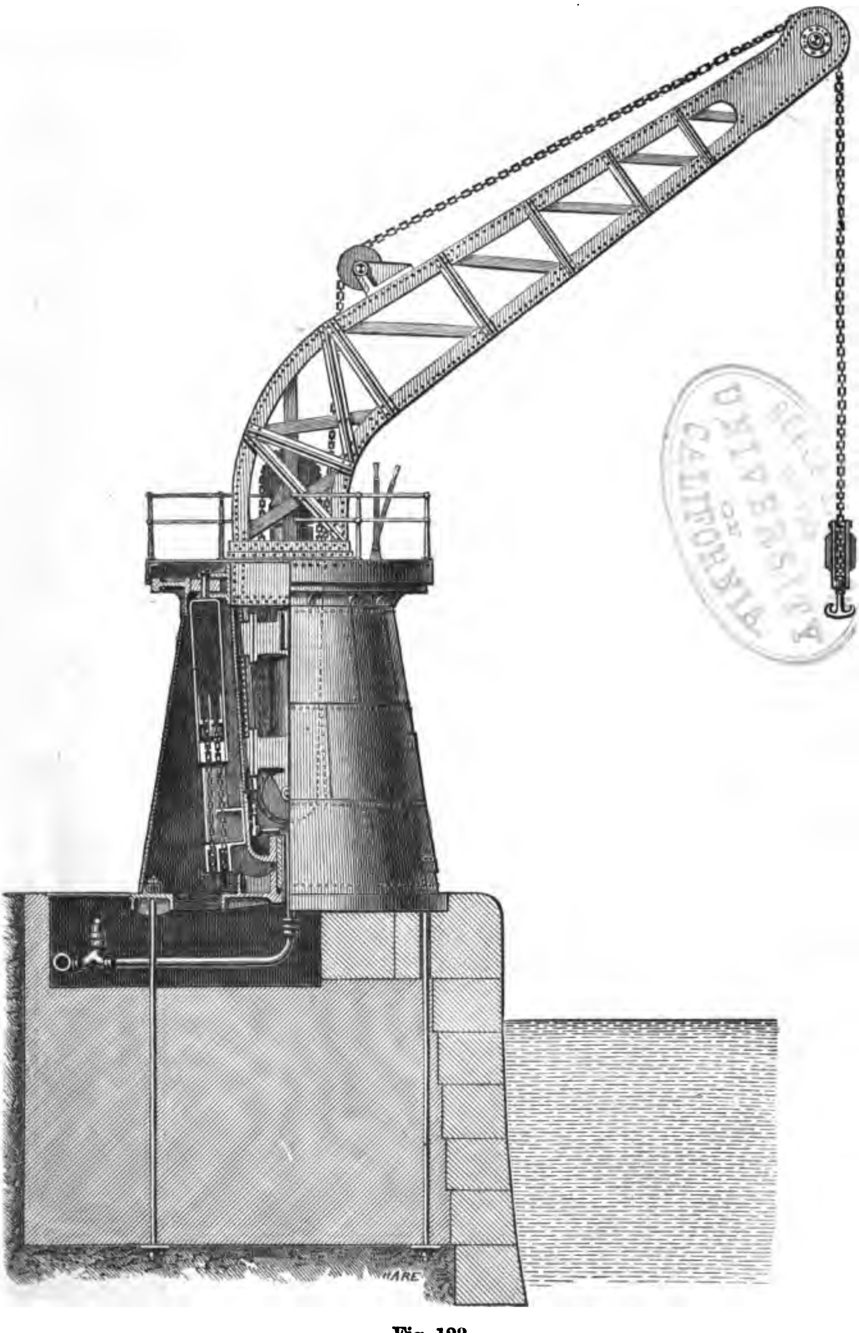
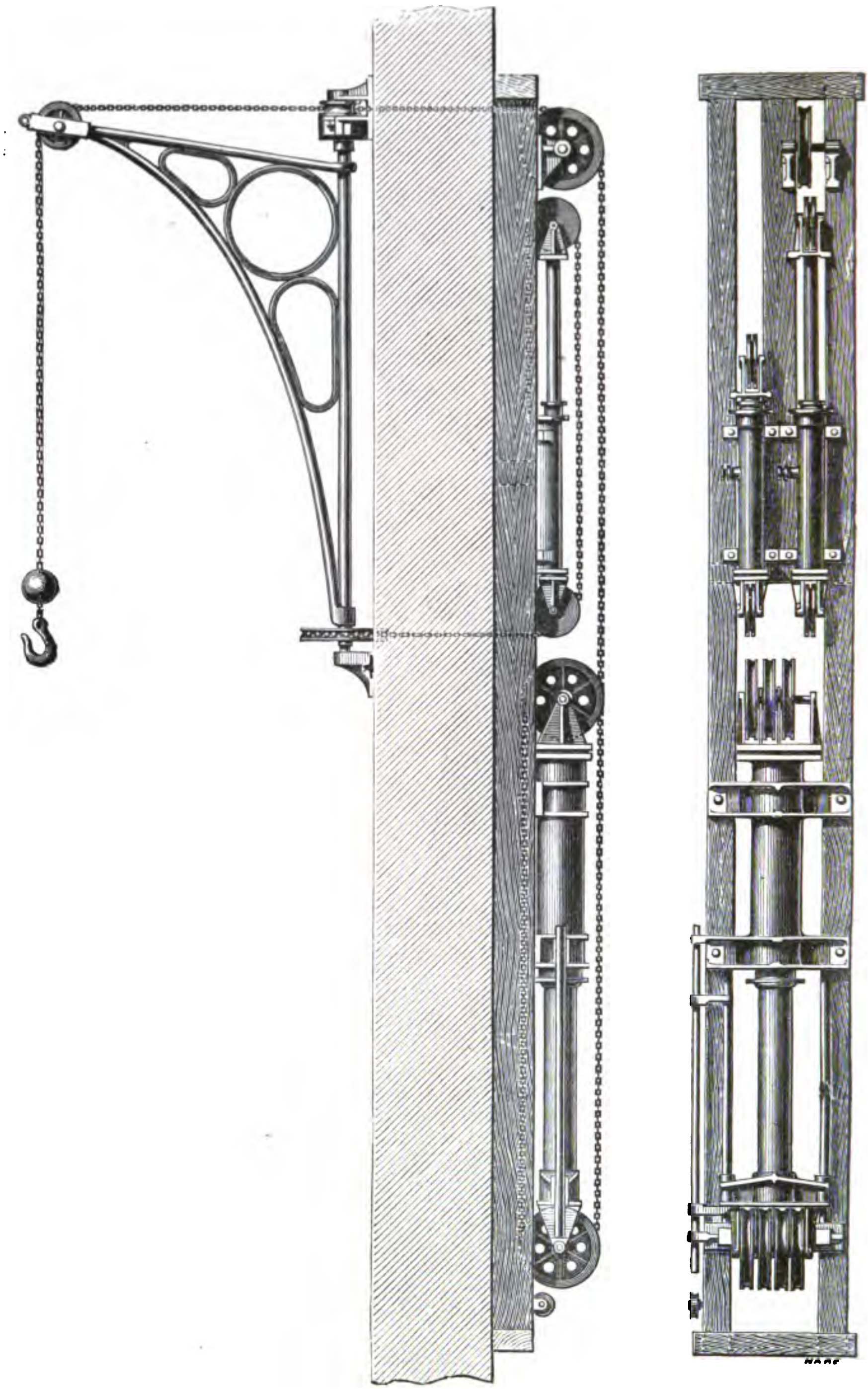


Fig. 123.



Side Elevation. *End Elevation.*

Fig. 124.

INDEPENDENT HYDRAULIC PLATFORM CRANE. A very simple and inexpensive form of independent hydraulic platform crane is made for lifting loads up to 30 cwt. a short distance, such as would be required for transferring goods from railway waggons on to the platform of a goods shed, or direct into vans or carts. The cylinder forms the column or crane post, and it is turned by hand power. These cranes are used at small stations, where an engine is constantly at work pumping water for the locomotives; and the same engine is utilised to drive a small pump in connection with a cheap form of accumulator of sufficient size to work one or two cranes only.

The price of one crane, pump, and accumulator, is £180.

The price for two cranes, with pump and accumulator, is £250.

HYDRAULIC WAREHOUSE CRANE, Fig. 124. These cranes are usually fixed against the outside wall of a warehouse to a timber framing, as shown by the side and end elevations, and in connection with a swing crane jib on the outside of the warehouse. The jibs are frequently of greater sweep than that shown, built up of plate and angle-iron, and fixed in a *central* position between two tiers of doors, one crane being thus made available for both sets of doors. The top pair of cylinders shown are used for slewing or turning the jib, and the bottom cylinder and ram for lifting the load. The illustration is taken from a number of cranes constructed and erected in an extensive range of wool warehouses in the East and West India Docks.

As these cranes are required of all powers, height of lift, and radius of jib, it is impossible to make a complete price list, but the prices of the cranes in question are given with and without slewing gear.

Power of crane	12 cwt.	20 cwt.
Height of lift	28 ft.	28 ft.
Radius of crane jib	6 ft.	6 ft.
Price without slewing gear	£125	£150
Price with " "	£165	£200
Approximate weight of each	2 tons	2½ tons
" measurement of each	80 cubic ft.	100 cubic ft.

Prices, &c. of hydraulic lifts and hoists, see pages 96 to 99.
Prices, &c. of crane jibs, see pages 46 and 47.

HYDRAULIC PORTABLE CRANES are practically as yet a thing of the future, but the Authors have recently taken out letters patent for a crane which will probably to a great extent take the place of the large number of fixed hydraulic cranes now required wherever the hydraulic system is adopted.

To carry this system into effect, the pressure mains will be laid in the centre of a line of rails, or parallel to it on one side, and a simple form of high-pressure hydrant will be fixed at any of the joints, which will be at convenient distances apart. The crane will have a corresponding pipe connection, which, when attached, will force inwards the valve of the hydrant, and, when disconnected, this valve will come back to its seat and retain the pressure in the mains. The pipe can thus be taken through the crane post in the usual manner to the cylinders for lifting and slewing.

Another method is adopted when the crane is required to be in motion on the rails at the same time as it is actually in work. The connection between the hydrants on the pressure mains and the crane would then be made by a flexible tube, fitted with a self-coiling and uncoiling apparatus. This system is equally adapted for working hydraulic or compressed-air travellers, single-rail cranes, &c. for use in workshops, warehouses, and goods stations; and it will be evident that such a system gives great facilities for concentrating the lifting power at any given point, and fewer cranes being required will, at the same time, effect a great reduction in the cost, compared with a fixed plant of machinery to do the same duty.

HAND-POWER FIXED CRANES. The same general construction and arrangement is adopted for all powers, from 2 to 30 tons, the proportions only being varied for each power; and the working parts are so clearly shown in the accompanying engravings that a detailed description will be unnecessary.

Fig. 125 is a 15-ton crane.	Fig. 127 is a 3-ton crane.
Fig. 126 is a 10-ton crane.	Fig. 128 is a 2-ton crane.

All these cranes have solid wrought-iron pillars, and are fitted with gearing of the most careful construction, proportioned to lift the maximum load with a moderate expenditure of power on the handles.

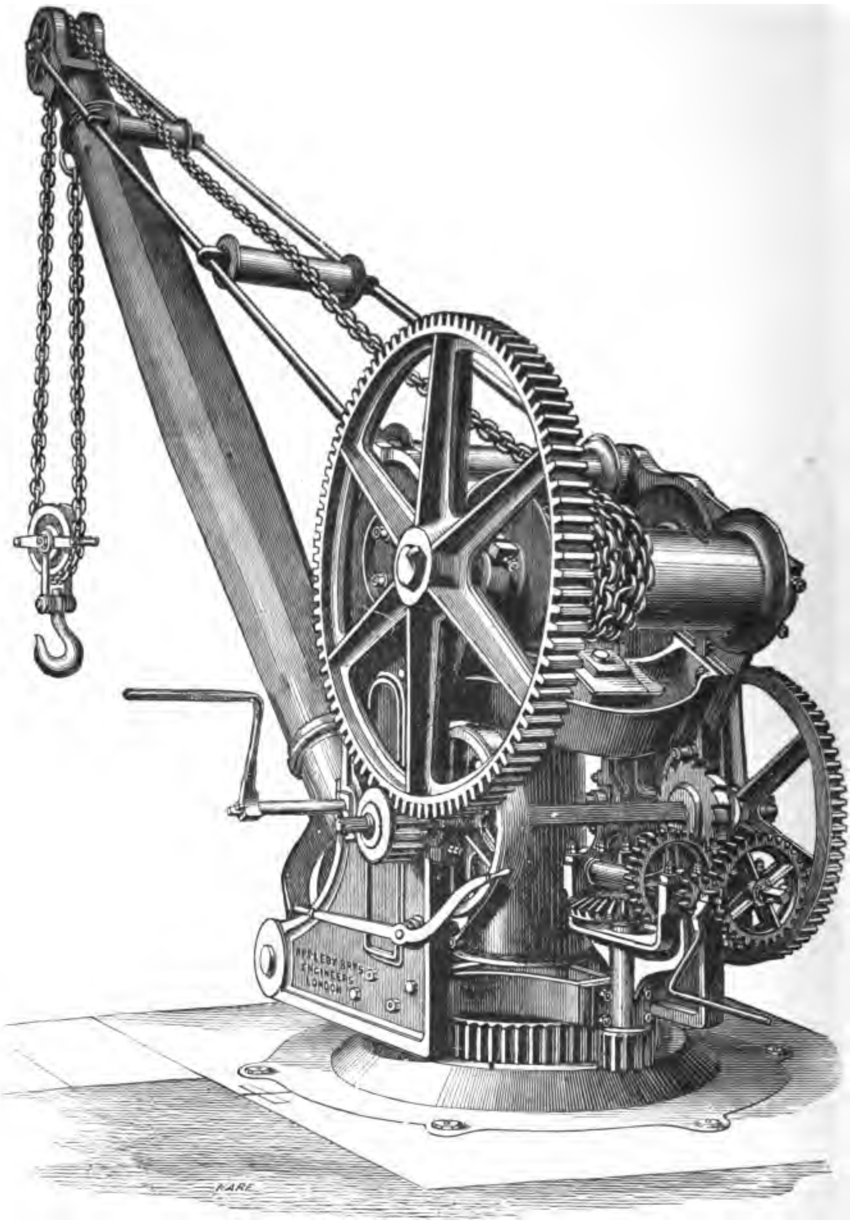


Fig. 125. (*For prices, see pages* 40 *and* 41.)

Too much care cannot be taken with the gearing of hand cranes, although the reverse is too often the case, and it is not unusual to find a power crane with properly formed toothed gearing, good bearings, &c., everything, in fact, to reduce the friction to the lowest possible limit, whilst hand cranes will have badly constructed gearing, indifferent bearing surfaces, and altogether made as

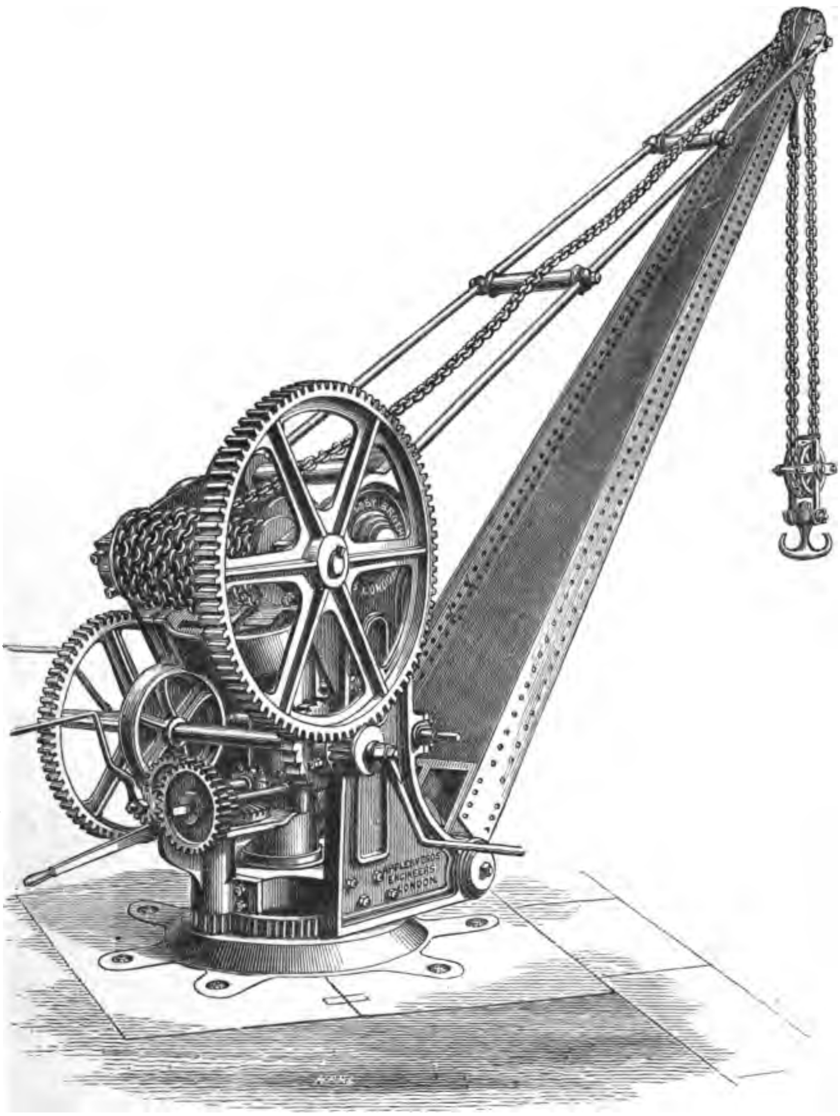


Fig. 126. (*For prices, see pages* 40 *and* 41.)

if anything was good enough for a hand crane, utterly disregarding the fact that the limited amount of power available with hand labour renders it imperative that the utmost care should be taken to make it as productive as possible. With this view all the shafts have gun-metal bearings of good length, fitted with loose caps and bolts, and lock-nuts where practicable. The cranes for 25 to 30 tons have treble-purchase gearing, and the chain can be used with a single sheave block and treble chain, treble-purchase slewing gear, screwed chain barrel, friction sheave at foot of jib and back of post, and double timber jibs. The cranes from 10 to 20 tons have double-purchase lifting and slewing gear, and lift the maximum load with block and double chain, friction wheel at foot of jib and back of post, and the jibs are of a single timber. See Fig. 125.

The cranes from 5 to 8 tons have also double-purchase lifting gear, double slewing gear,

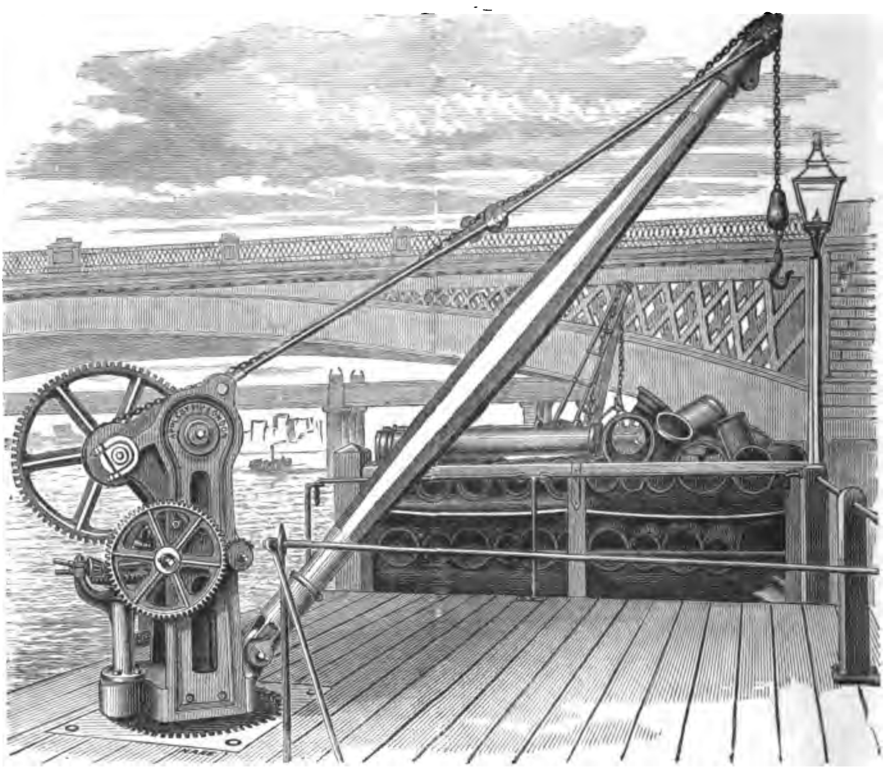


Fig. 127.

friction wheel at foot of jib, but not at back of post; they lift the full load with return chain, and have single timber jibs. The 3-ton and 4-ton cranes, Fig. 127, have double-purchase gearing, lifting the loads with single chain, but no friction rollers at foot of jibs, and the slewing gear is single purchase. The 2-ton crane, Fig. 128, is as described for 3 and 4 tons, but without slewing gear.

All sizes are fitted with wood-lined strap brake, pawl and ratchet wheel on the second-motion shaft, giving ample power to hold the load suspended in safety, or to lower it under full command by the brake. The chains are of the best tested short-link kind, reach 15 feet below ground-line, and are properly proportioned to the power of the crane. The running block (when used), ball and hook or ram-head, foundation bolts, and bottom toe-plates, for pillar, in short, everything to render the crane complete, ready for fixing, is supplied and included in the prices quoted below.

Power of crane	2 tons	3 tons	4 tons	5 tons	6 tons	8 tons
Radius of jib	12 ft.	14 ft.	14 ft.	14 ft.	15 ft.	16 ft.
Powers of lifting gear ..	Double	Double	Double	Double	Double	Double
Single, double, or treble chain	Single	Single	Single	"	"	"
Single, double, or treble slewing gear	—	—	—	—	"	"
Double or single jibs ..	Single	Single	Single	Single	Single	Single
Price of crane	£80	£120	£140	£160	£190	£250
Price extra if with iron jib	£5	£6	£7	£8	£9	£10
Approximate weight ..	2½ tons	3½ tons	4½ tons	5 tons	6 tons	8 tons
" measurement	120 cub. ft.	160 cub. ft.	180 cub. ft.	210 cub. ft.	250 cub. ft.	300 cub. ft.

Power of crane	10 tons	15 tons	20 tons	25 tons	30 tons
Radius of jib	16 ft.	16 ft.	18 ft.	20 ft.	25 ft.
Powers of lifting gear ..	Double	Double	Double	Treble	Treble
Single, double, or treble chain	"	"	"	"	"
Single, double, or treble slewing gear	"	"	"	"	"
Double or single jibs ..	Single	Single	Single	Double	Double
Price of crane	£350	£450	£600	£700	£850
Price extra with iron jib	£15	£20	£30	£40	£50
Approximate weight ..	10 tons	15 tons	20 tons	25 tons	30 tons
" measurement	350 cub. ft.	400 cub. ft.	450 cub. ft.	500 cub. ft.	600 cub. ft.

The first four sizes, 2 to 5 tons, can be made with slewing gear at an extra cost of £8 to £12.

The bed plate can be adapted to suit timber jetties or piers at the same cost as given in list.

The cost of packing for shipment is from 3 to 5 per cent.

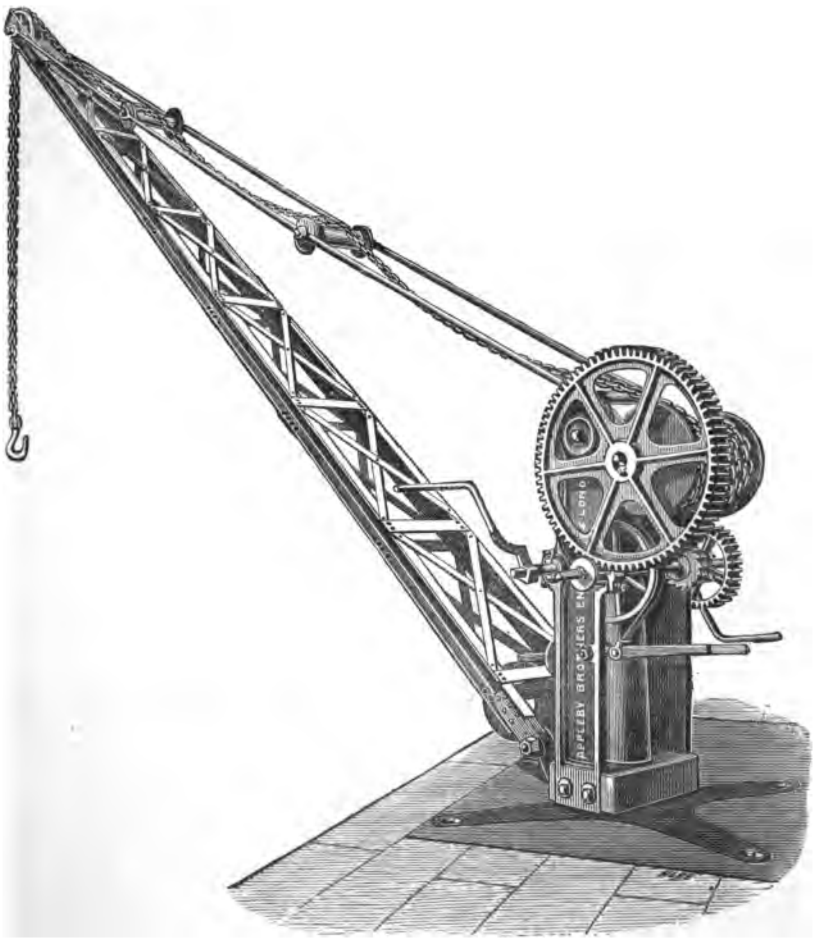


Fig. 128.

HAND-POWER SHIP'S DECK CRANE. These cranes are of the same patterns as Fig. 128, excepting that for use on board ship, a round oak jib is preferred to the iron jib shown, as being more readily shipped and unshipped; and as this is generally done each voyage, a handy attachment of the tie rods to the frame is provided for the purpose. The wrought-iron pillar is made to extend 8 ft. below deck-line; the cast-iron base plate is a special pattern, suitable for bolting to the ship's deck, and a toe-plate is provided for the bottom of the post; chain of suitable strength to reach 20 ft. below deck-line, with hook and cast-iron ball, is sent with each crane. The post can be made longer when desired.

The usual sizes are 2 and 3-ton cranes, and the prices are the same as quoted for wharf cranes, page 40.

Ship's hand winches, see page 141 to 145.

Ship's steam cranes, see pages 8 and 9. Ship's steam winches see pages 126 to 141.

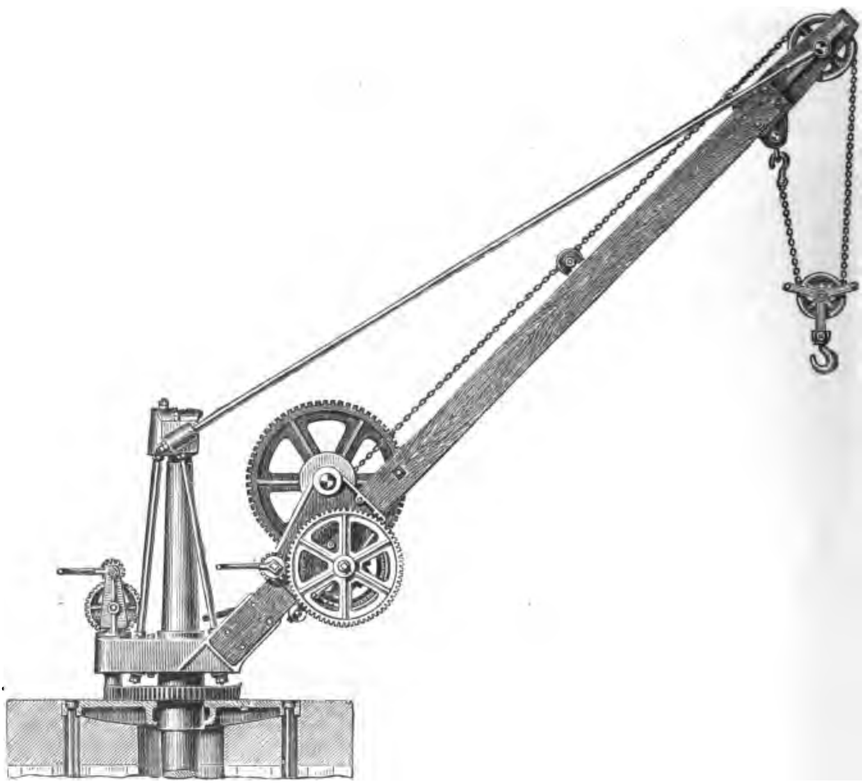


Fig. 129.

The **FIXED CRANES,** Fig. 129, have been designed with a view of reducing the cost without sacrificing the general efficiency referred to at page ; and this is attained by fixing the lifting gear to the jib and using wrought-iron ties, as shown, to connect the revolving bed and top cap, thus dispensing with side frames.

The crane, Fig. 129, is of 5-tons power; the lifting and slewing gear is the same as is used in the cranes described at page 39, but it is carried in castings firmly secured to the jib as shown; the bearings are of extra length, bored out, but not fitted with open gun-metal bearings; they can however be bushed with gun-metal at the extra cost stated in the list of prices. The post is of hammered scrap iron of ample section to carry the load with safety; the base plate is a massive casting, and a toe-plate of the same size is provided to take the toe of the post or pillar; also foundation bolts, passing through both the plates in order firmly to bind together the foundations. These may be in masonry, brickwork, or good concrete.

Chains, hooks, balls, and return block, where required, are included in the prices. These cranes are made in the following sizes :—

Power of crane	3 tons	4 tons	5 tons	6 tons	8 tons	10 tons
Radius of jib	14 ft.	14 ft.	14 ft.	15 ft.	16 ft.	16 ft.
Single or double purchase	Double	Double	Double	Double	Double	Double
Single or double purchase slewing gear . ..	—	—	—	"	"	"
Single or double lifting chains	Single	Single	Double	"	"	Treble
Price of crane	£90	£105	£120	£150	£200	£275
Price extra if brass-bushed bearings	£3	£4	£5	£6	£8	£10
Approximate weight ..	3 tons	4 tons	4½ tons	5 tons	7 tons	9 tons
" measurement	120 cub. ft.	160 cub. ft.	210 cub. ft.	250 cub. ft.	300 cub. ft.	350 cub. ft.

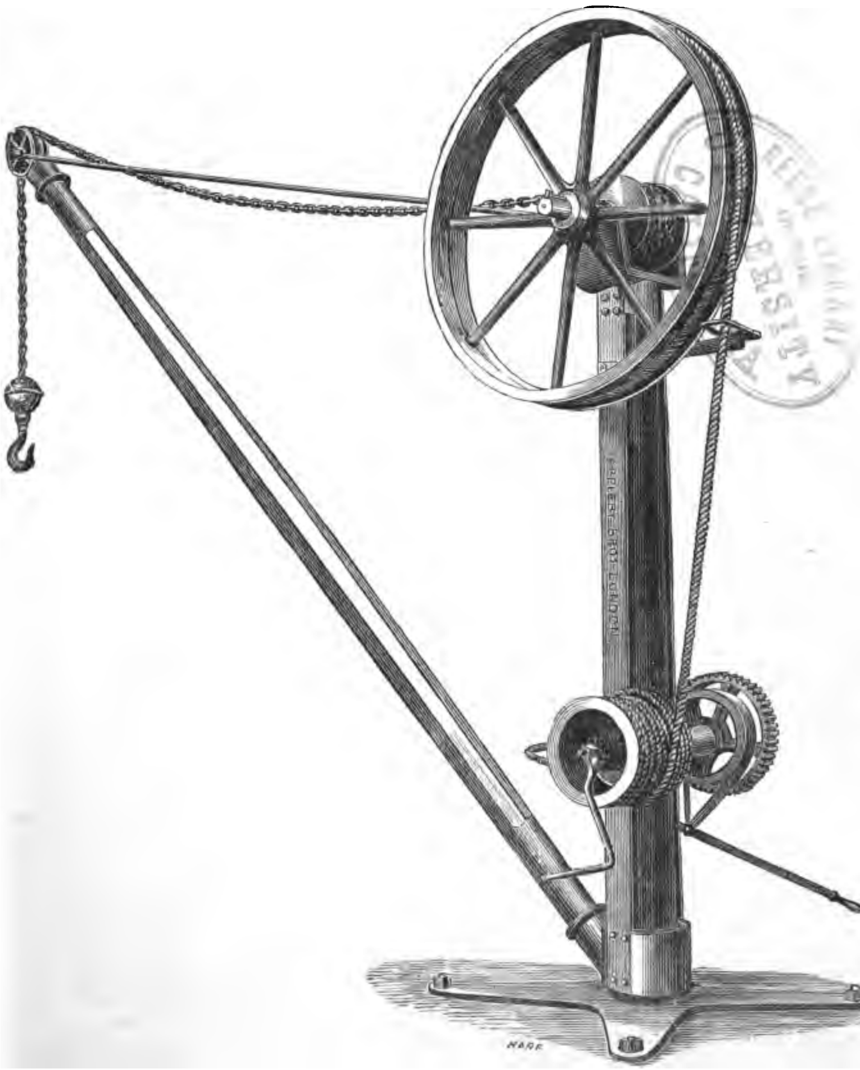


Fig. 130.

INDEPENDENT WHIP CRANE, Fig. 130 (No. 3). This crane was constructed for the Central Argentine Railway, where the goods sheds were lofty, and the roofs so light in construction that no support could be obtained at the top; but it is equally suitable for docks and other places where light weights have to be lifted quickly.

It stands quite independent of top support, swings completely round, and is fitted with three purchases or speeds of lifting, break apparatus, &c. Weights up to about 5 cwt. are lifted quickly by pulling directly at the rope; for working loads up to 1 ton, the handle is put on the rope-barrel shaft, and, for heavier loads, on the pinion shaft.

Power of crane	1 ton	2 tons	3 tons
Radius of jib	12 ft.	12 ft.	12 ft.
Clear height of lift	10 ft.	10 ft.	10 ft.
Price of crane complete	£50	£60	£70
Approximate weight of crane	2 tons	2¼ tons	3 tons
„ measurement	80 cubic ft.	85 cubic ft.	90 cubic ft.

Prices include chain to ground-line, ball and hook, hauling rope, and foundation bolts.

The **WHIP CRANE**, Fig. 131, has lifting gear of the same construction as that shown in Fig. 130; but this crane is supported above, and is not made independent of top support. The upright and jib are of pitch pine timber, with cast-iron shoes top and bottom, wrought-iron pivots, and square cast-iron plates for fixing to floor and beam. The jib is fitted with cast-iron bracket and jib-head, and wrought-iron tie rods to the top pivot casting. Each size is complete with chain, hook, and ball. Cranes of this type are used very extensively at small goods stations, and for short lifts, such as are required on a goods platform. A better and cheaper form of hand crane can scarcely be desired. The form of jib gives good clearance for bulky packages.

Power of crane	1 ton	2 tons	3 tons
Radius of jib	12 ft.	12 ft.	12 ft.
Height of lift of chain	10 ft.	10 ft.	10 ft.
Price of crane complete	£35	£45	£60
Approximate weight..	1¼ ton	1¾ ton	2 tons
„ measurement	80 cubic ft.	85 cubic ft.	90 cubic ft.

HAND-POWER WAREHOUSE CRANES, Fig. 132 (No. 71). The general arrangement of cranes of this class, and the position in which they are fixed in a warehouse, is clearly shown in Fig. 132. It is, however, desirable, where possible, to place the lifting gear on the floor below that on which the jib is fixed, as this gives "a better lead" for the chain on the chain barrel. It can also then be fixed close up to the wall, and not occupy so central a place in the warehouse, which is often valuable space.

The whole of the gearing is carried on two cast-iron stanchions, provided with bearings for the reception of the various shafts, the bearings being of gun-metal, with loose cap and lock-nuts. Two speeds or powers of lifting are shown in the engraving, both of which are single purchase, and this arrangement is frequently adopted for light loads and a high speed of working; but the heavier cranes are fitted with single and double gear, the pinions being made to slide in and out of gear with a hand lever. The barrel is of large diameter, to reduce the wear of the chain, as well as all the carrying pulleys in the wall carriages and jib; the barrel is fitted with large strap friction brake for lowering, a rope and lever, admitting of the brake being applied from any floor; the handle shaft is fitted with a heavy fly-wheel and two handles.

Where a quantity of goods has to be lowered from upper floors, these cranes are fitted with a self-acting apparatus to run up the chain; this consists of a counterweight, sliding in a wooden casing against the wall, and a chain from it is attached to a fuzee sheave on the end of the barrel shaft. This sheave is fixed to the shaft by a clutch (when it is required for lowering only), and as the load on the crane ascends, the lifting chain runs off the barrel, the chain of the counterweight being at the same time wound up, and the counterweight is thus lifted. When the load is removed and the brake eased off, the counterweight runs up the chain ready for lowering the next load. As the crane man has only to raise a heavy weight (such as a hogshead)

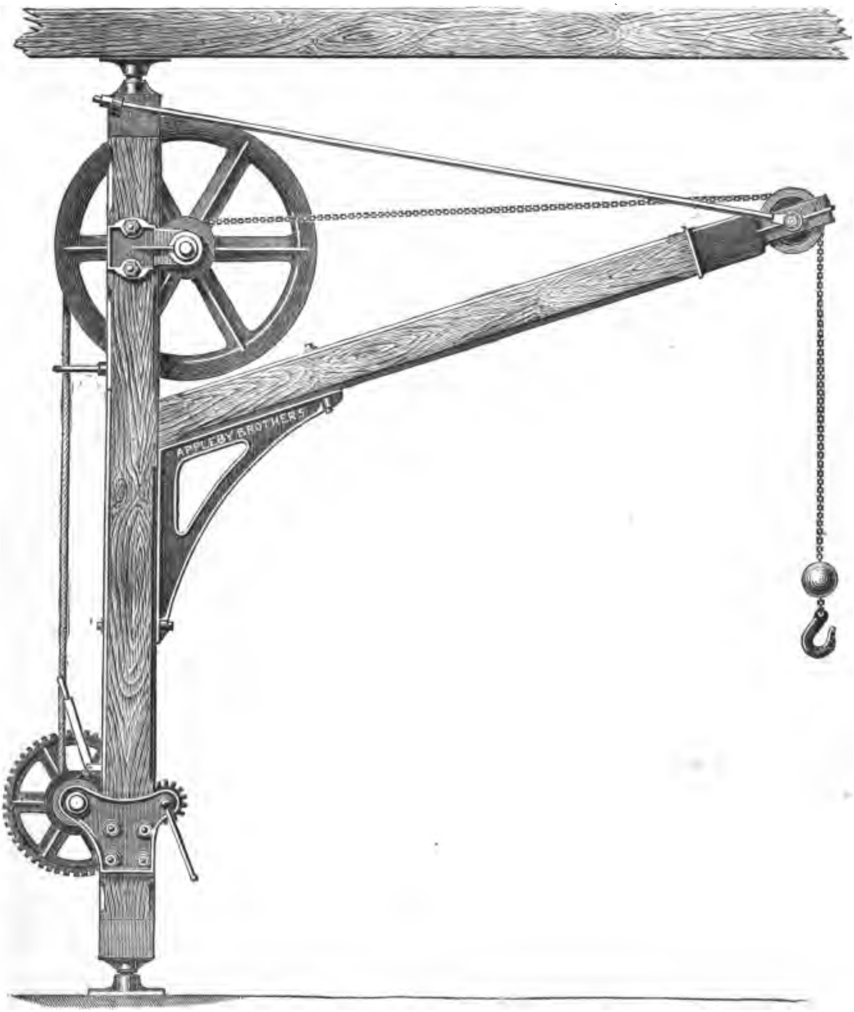


Fig. 131.

a few inches, sufficient to clear the floor and swing out, one attendant will lower out a great quantity of merchandise with a crane provided with this apparatus.

The prices given are for stanchions 10 ft. high, a lift of 40 ft., and the jib of 6 ft. radius, with chain, &c. complete. But these conditions are continually altering, the lift often being 70 ft., and the jib 10 or 12 ft.; the list of prices must therefore only be regarded as applying accurately to the proportions given. These cranes are frequently fixed on the discharging side of warehouses, the goods being *lifted* by steam or hydraulic cranes; they then form a useful adjunct to the cranes. Figs. 106 and 107, pages 10 and 11. A cheaper crane can be made by using a crab winch (see Figs. 216 to 220, pages 141 to 145) in connection with the crane jib, but the remarks already made with reference to the necessity for having only the very best construction and design of gear to be used by hand-power again apply here, especially when the height of lift is great. It is a very laborious operation to lift a ton 70 ft. high by hand, and not an atom of such power should be absorbed by unnecessary friction.

Power of crane	10 cwt.	15 cwt.	20 cwt.	30 cwt.	40 cwt.
Height of lift	40 ft.	40 ft.	40 ft.	40 ft.	40 ft.
Radius of jib	6 ft.	6 ft.	6 ft.	6 ft.	6 ft.
Price of crane	£33	£35	£40	£45	£50
Price of crane with counter-weight	£43	£45	£55	£62	£70
Approximate weight ..	2 tons	2¼ tons	2½ tons	3 tons	3½ tons
„ measurement	80 cub. ft.	85 cub. ft.	100 cub. ft.	120 cub. ft.	140 cub. ft.

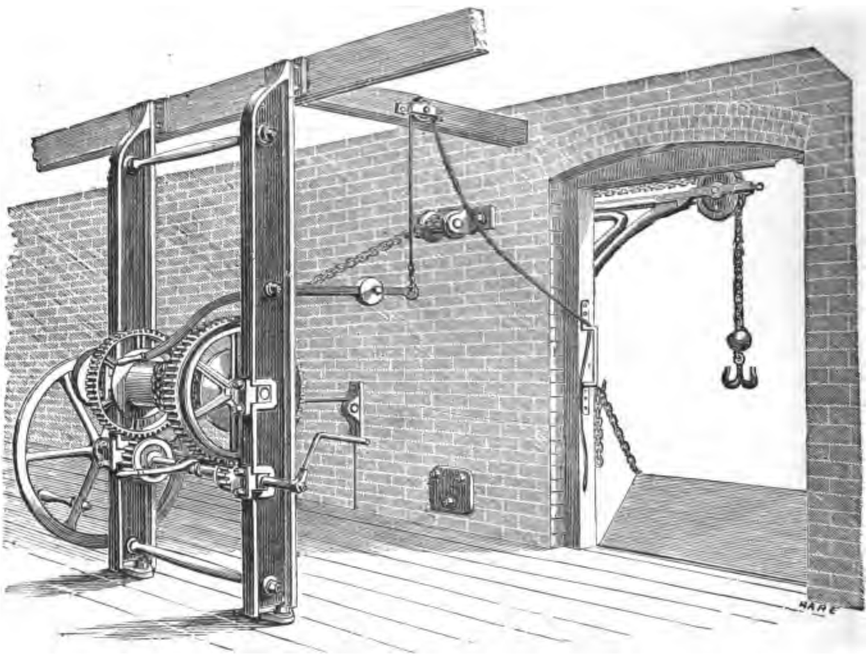


Fig. 132.

WROUGHT-IRON WAREHOUSE CRANE JIB, Fig. 133. The prices given below are for jibs of 6 ft. radius, with the wall carriages and sheaves shown. The sheaves are all bored, and work on turned pins; the top and toe of the back standard are also turned. The prices are exclusive of wall bolts or chains.

Crane jib to carry loads of	10 cwt.	15 cwt.	20 cwt.	30 cwt.	40 cwt.
Radius	6 ft.	6 ft.	6 ft.	6 ft.	6 ft.
Price	£12	£13	£14	£15	£17
Approximate weight ..	5 cwt.	5½ cwt.	6 cwt.	7 cwt.	9 cwt.
„ measurement	20 cub. ft.	22 cub. ft.	24 cub. ft.	28 cub. ft.	35 cub. ft.

These crane jibs are constructed of round iron, and for a small radius up to 7 ft. or 8 ft. have a neat appearance. The curved form gives good clearance for bulky packages in contracted doorways, but for jibs of greater radius it is usual to employ a square back standard, and flat iron straight bars for the jib, braced together, and round iron tension bars. This form again gives place to jibs constructed of plates and angle iron for the longest radius and heaviest loads.

CELLAR CRANES. The jib is fixed in the cellar and is made telescopic, so that the load is first lifted from any point within the radius of the crane, and is afterwards lifted and carried in a diagonal direction through the doors or flaps, until it is high enough to be deposited on the road or on a van. Many cranes of this construction are doing good service below chambers and in other positions where the use of an ordinary jib of the type Fig. 133 would not be permitted by the Local Board regulations, or where any such crane would interfere with architectural effect.

WAREHOUSE CRANES WITH VARIABLE RADIUS. The jib is made with the arm jointed at the bottom of the back standard, and gear is fixed inside the building, which admits of this arm being so manipulated as to give a variable radius with or without the load suspended on the crane. This construction is used when the jib must be fixed near to a door, but must reach over a footpath below to pick up or deposit a load. Also where two doorways must be served at different distances from the centre of the crane.

COLUMN CRANES. Jibs are frequently attached to and can, if necessary, be made to swing entirely around the columns in warehouses or factories; in some cases it is convenient to traverse the load on the jib in the manner indicated in Fig. 136. This arrangement is economical in cost as well as in the space occupied.

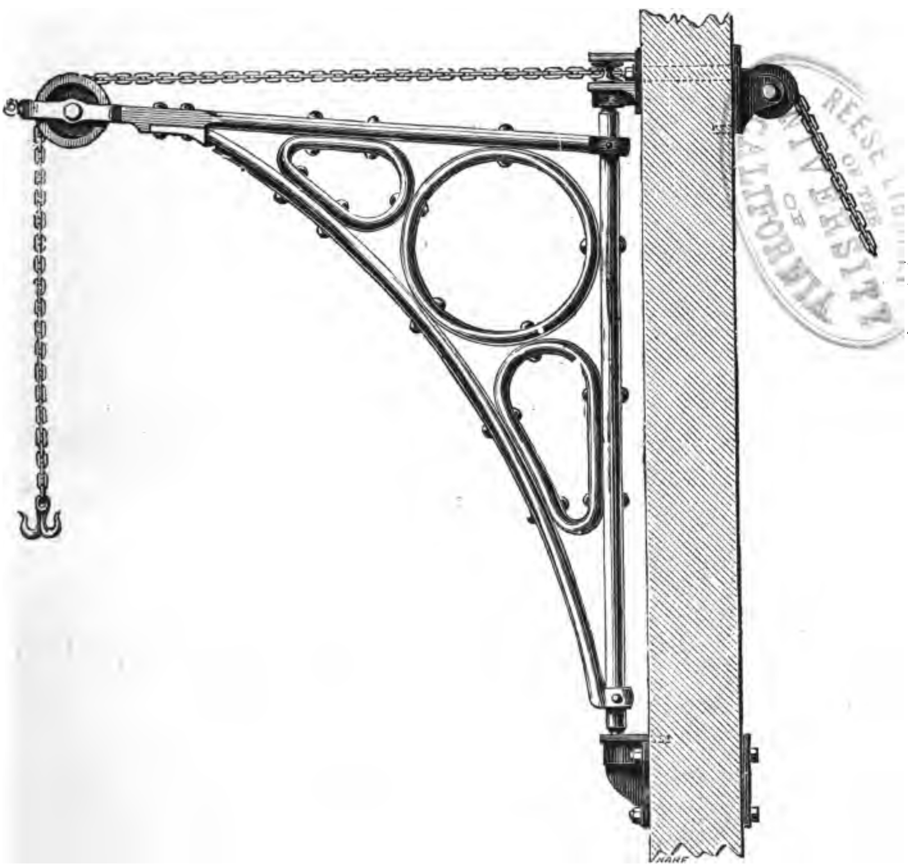


Fig. 133.

WROUGHT-IRON JIB CRANE, WITH CRAB, Fig. 134 (No. 70), is used for working loads through a trap-door in a warehouse, or is fixed against an outside wall, to raise goods from a cellar-trap; the top post is supported from the wall by a wrought-iron bracket, but if placed

between two floors, it would have a plate at the top, similar to that shown at the bottom. It is fitted with single and double-purchase gear, brake and chain, pawl and wheel, to hold the load.
The variations in height and radius are so numerous that a complete price-list cannot be given, but a crane of 20-cwt. power, 7 ft. radius × 7 ft. high, costs £25.

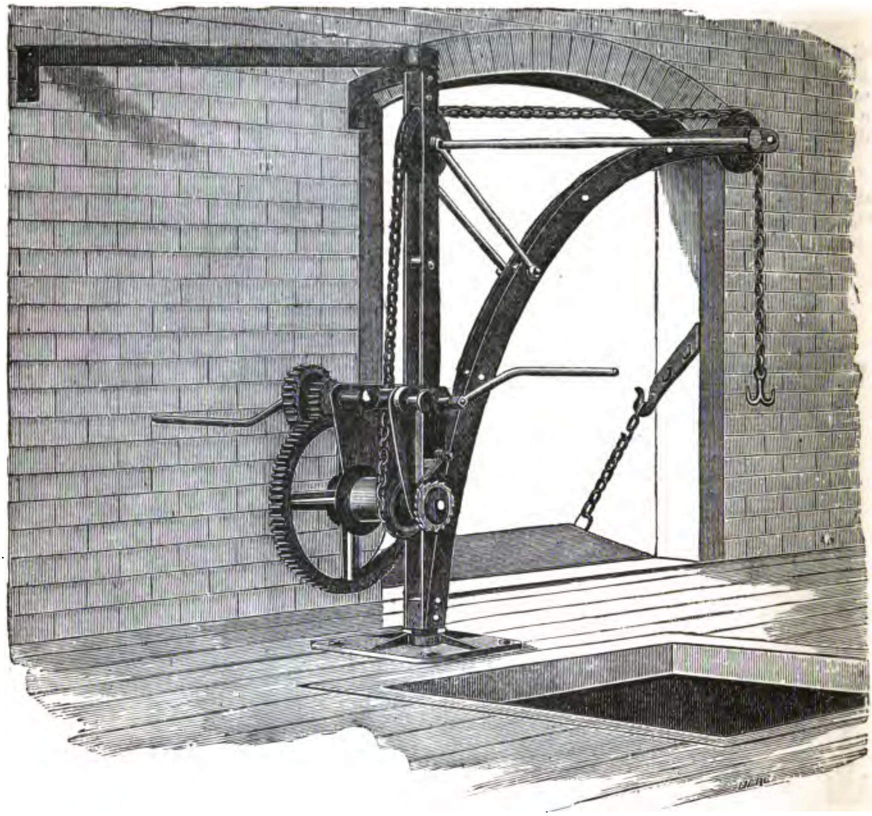


Fig. 134.

WOOD FRAME HAND-POWER FOUNDRY CRANES, Fig. 135. The jib is fitted with cast-iron sockets, and the mast is hooped top and bottom with wrought iron, where the gudgeons are inserted, and the crane is complete with racking in and out motion, top and bottom pivot plates, chains, blocks, &c. as shown.

Power of crane	5 tons	6 tons	8 tons	10 tons
Radius over all	15 ft.	16 ft.	18 ft.	20 ft.
Price complete	£130 0 0	£150 0 0	£180 0 0	£200 0 0
Price for all ironwork	£100 0 0	£110 0 0	£130 0 0	£150 0 0
Approximate weight	5 tons	6 tons	7 tons	8 tons
„ measurement ..	300 cubic ft.	350 cubic ft.	400 cubic ft.	450 cubic ft.

Steam foundry cranes, see pages 12 and 13.
For general remarks on foundry cranes, see pages 11 to 13.

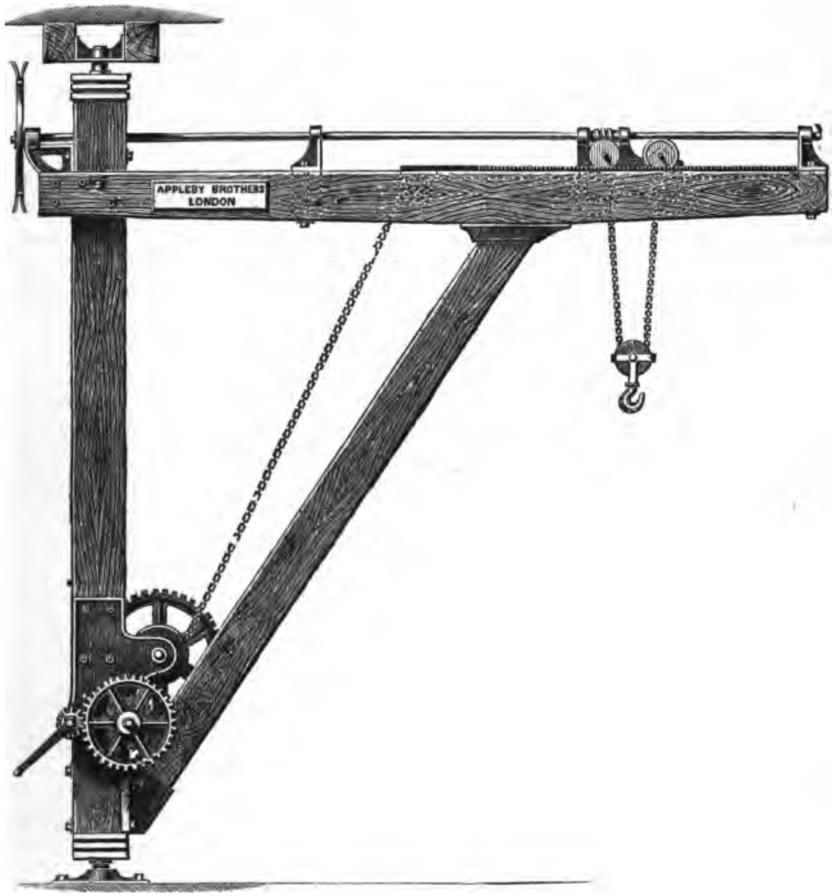


Fig. 135.

WROUGHT-IRON FORGE OR FOUNDRY CRANES are made in exactly the same manner as the steam foundry cranes, Fig. 108, and referred to at page 13, excepting only that the engines are omitted. The subjoined prices include all the fittings required for efficient working.

Power of crane ..	3 tons	5 tons	10 tons	15 tons	20 tons	25 tons
Radius of crane, in feet, from centre to extreme points ..	16 ft.	18 ft.	20 ft.	20 ft.	20 ft.	20 ft.
Price of crane ..	£90 0 0	£200 0 0	£300 0 0	£375 0 0	£450 0 0	£550 0 0
Approximate weight	2 tons	4 tons	7 tons	10½ tons	13 tons	16 tons
" measurement	250 cub. ft.	350 cub. ft.	450 cub. ft.	500 cub. ft.	500 cub. ft.	500 cub. ft.

HAND-POWER FOUNDRY OR FORGE WALL CRANE, Fig. 136. A number of these cranes may be fixed on the walls, piers, or columns of a foundry or forge, and in such a position that an overhead traveller will pass over them. For use in foundries several cranes placed diagonally with each other on the two opposite walls are exceedingly useful for light work; the central part of the floor is thus kept clear for the heavier class of work, and by means of an over-

head traveller, which is usually fully occupied in lifting heavy flasks and ladles, removing boxes, &c., the whole of the floor space is available for casting, and the services of the traveller are not required for work which can be performed as well, or perhaps better, by these lighter cranes. These cranes have been adopted in several foundries for which the Authors have designed and made the lifting machinery, and in all the commercial results obtained have been highly satisfactory.

Power of crane	1 ton	2 tons
Radius over all	20 ft.	20 ft.
Price with chains, blocks, crab, and racking motion	£75 0 0	£85 0 0
Approximate weight	2½ tons	3 tons
" measurement	80 cubic ft.	100 cubic ft.

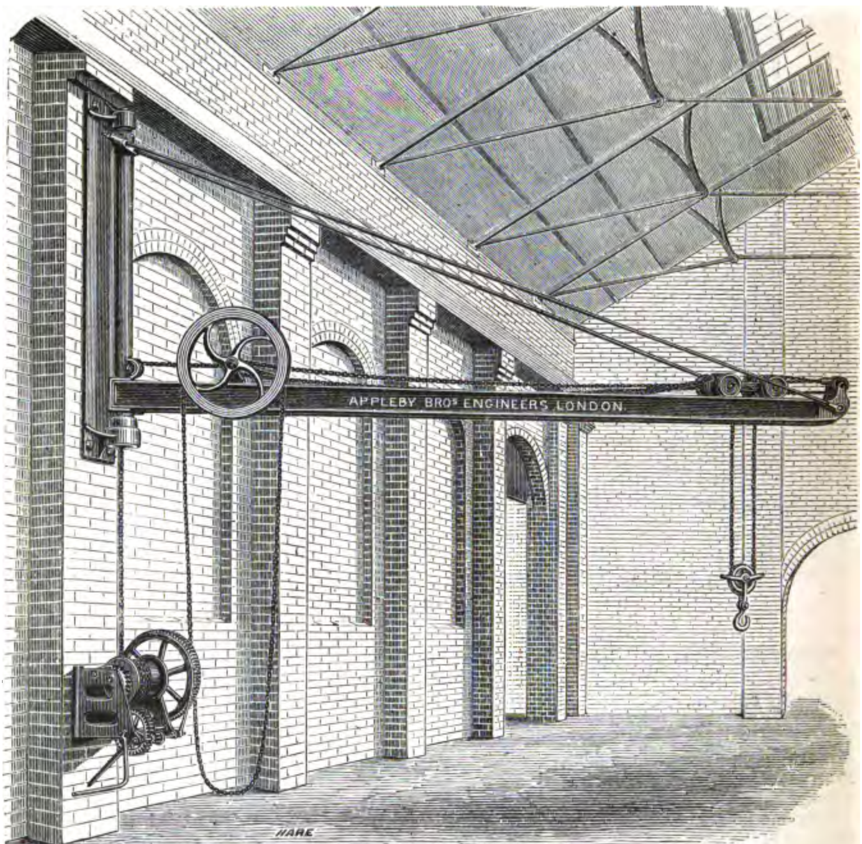
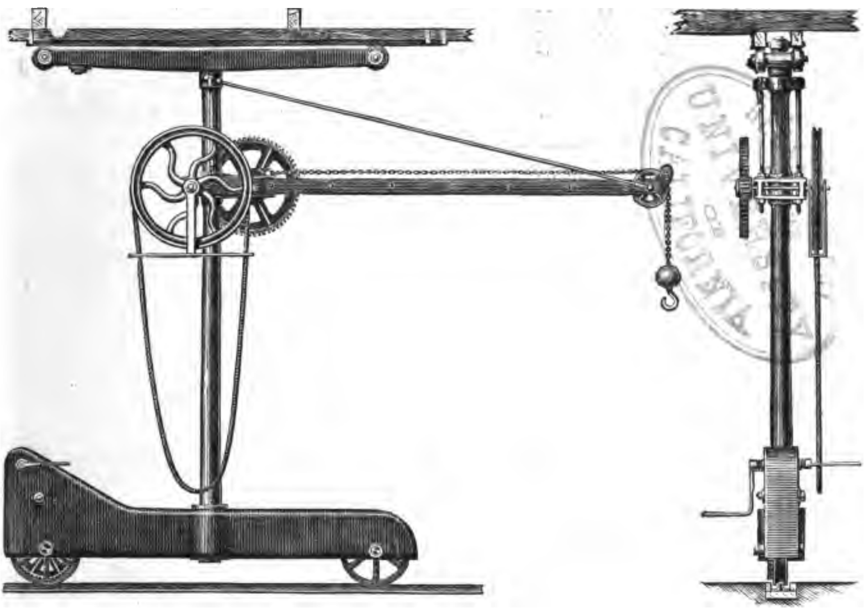


Fig. 136.

SINGLE-RAIL CRANES, Fig. 137. This form of crane, although probably novel to many, has been very successfully used for a variety of purposes, and is adapted to work by hand or by power. The crane shown in Fig. 137 is for hand power, but the general form is the same whether the crane is worked by hand or is driven by a high speed cord or tumbler shaft. The under carriage or bogey is fitted with two double flanged wheels one in front of the other and travelling on a *single rail*, which is usually sunk so as to be flush with the floor, in order not to interfere with the free circulation of foot or wheeled traffic in any direction; the stability of the crane is

maintained by the post being keyed securely into the carriage, its upper end being fitted with a horizontal wheel which works between a pair of guides fixed to the underside of a floor, or to the beams or columns; these guides are fixed in the same line as the single rail on the floor and plumb above it, and extend the full length that it is desired to travel the crane; the jib is hung on a shoulder on the post, the thrust of the jib being taken by a pair of friction rollers working against the post; it therefore turns very freely entirely round the post. The gearing is worked from the floor by hauling on the endless hand-rope, and the barrel shaft is fitted with a self-acting arrangement, which maintains the load suspended directly the hand-rope is released. One of the travelling wheels is geared up to the handle shaft on the carriage, which is the proper height from the ground for easily turning.



SIDE ELEVATION END ELEVATION

Fig. 137.

It will be evident from the engraving and the foregoing short description that these cranes occupy so little space that they are peculiarly adapted for running between two lines of lathes or machine tools, or for lifting the smaller parts of machines in the erecting shop after the heavy portions have been put in position by the overhead traveller. Both of these operations are performed in the Authors' works, and cranes of this type have been constructed for many of the leading engineers; they are also usefully employed in wool warehouses or furniture stores where goods are packed from floor to ceiling. For the platforms of Railway or Dock goods sheds this system affords very great facility for concentrating the crane power at any given point, and the heavy outlay is avoided for a number of fixed cranes which can neither be always employed nor cover the ground so completely as portable cranes: and it should be mentioned that not only do these cranes lift a load and swing entirely round with it, but they can travel with it as readily as if it were on a tram trolley. The subjoined price list is for cranes worked by hand-gear as shown in Fig. 136.

Power of crane	10 cwt.	20 cwt.	30 cwt.	40 cwt.
Radius of crane	10 ft.	12 ft.	12 ft.	12 ft.
Height of crane	12 ft.	14 ft.	14 ft.	14 ft.
Price of crane	£65 0 0	£70 0 0	£80 0 0	£100 0 0
Approximate weight	2 tons	2½ tons	3 tons	4 tons
" measurement ..	45 cubic ft.	60 cubic ft.	70 cubic ft.	85 cubic ft.

HYDRAULIC SINGLE-RAIL CRANES. The Hydraulic pump is worked by hand, the lifting cylinder is placed on the jib, and the wrought-iron sides form the guides for the crosshead of the ram, the latter being fitted with chain sheaves, to multiply the length of lift in the ordinary way; the pressure on the ram is furnished by a pair of pumps of differential diameter, giving various speeds and powers and stroke; the pumps are supplied from a small cistern which forms part of the revolving portion of the crane. The lowering is performed by a small relief valve, and is controlled with great nicety; the whole arrangement is neat, but the first cost is greater than for geared cranes. The prices are as under:—

Power of crane	10 cwt.	20 cwt.	30 cwt.	40 cwt.
Radius of jib	10 ft.	12 ft.	12 ft.	12 ft.
Height of crane	12 ft.	14 ft.	14 ft.	14 ft.
Lift of chain	10 ft.	12 ft.	12 ft.	12 ft.
Price of crane	£70 0 0	£80 0 0	£100 0 0	£125 0 0
Approximate weight	2¼ tons	3 tons	4 tons	5 tons
,, measurement ..	50 cubic ft.	70 cubic ft.	85 cubic ft.	120 cubic ft.

The dimensions can of course be modified to suit almost any radius or height, and in the hydraulic arrangement, if the height of lift is less than that given, the lifting power can be proportionately increased.

SINGLE-RAIL CRANE DRIVEN BY POWER. Cranes driven by power either by the rope system or a shaft placed directly over the crane post, have in either case hollow posts, a vertical shaft passing through the centre to transmit motion to the lifting and travelling gear, and in the larger cranes, the turning or slewing is also taken from the same shaft. The price of a crane to lift, turn round, and travel (either by the high speed rope or shaft), to carry 5 tons, with a radius of 12 ft. and about 14 ft. high, is £300; but the powers, proportions, and arrangements for driving vary so much that it would be almost impossible to prepare a list of prices which would have any practical value.

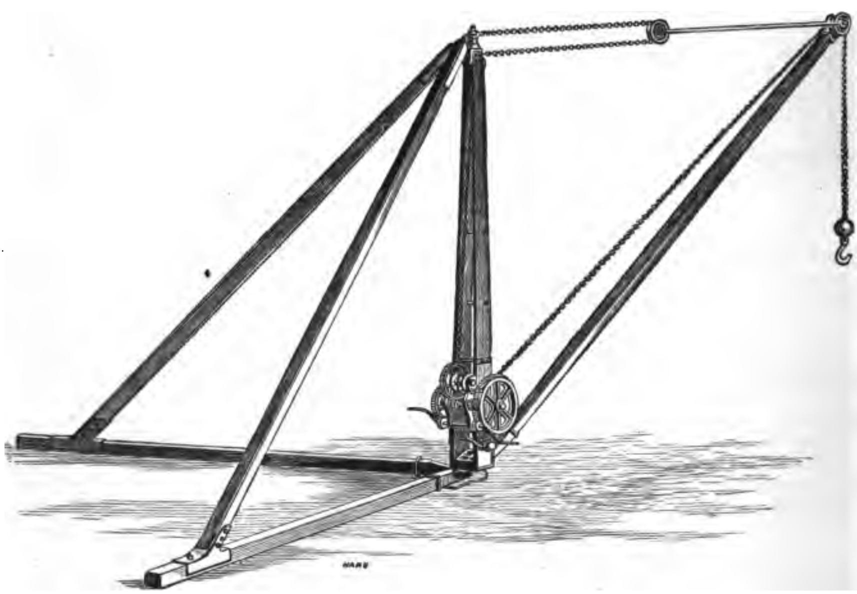


Fig. 138.

HAND-POWER DERRICK CRANES. The design, Fig. 138, is that usually adopted: the framing, jib, back-ties and sleepers are made of timber, and answer the purpose perfectly in most countries; but for use in tropical climates the construction in iron shown in Figs. 139 to 141,

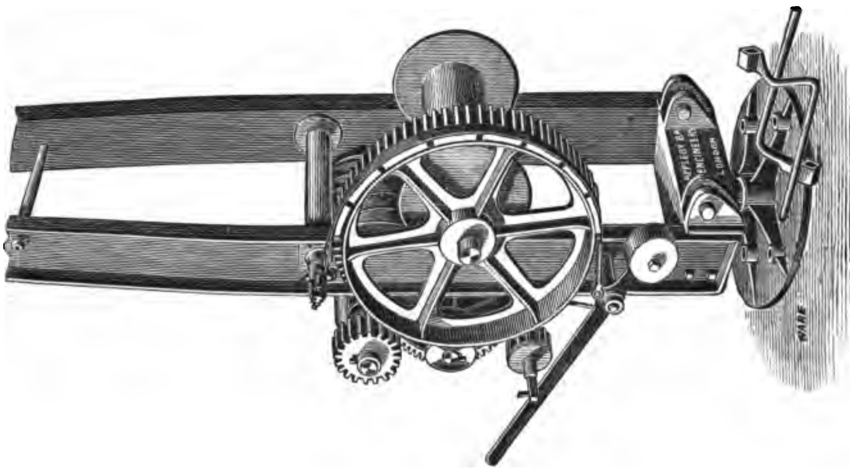


Fig. 141.

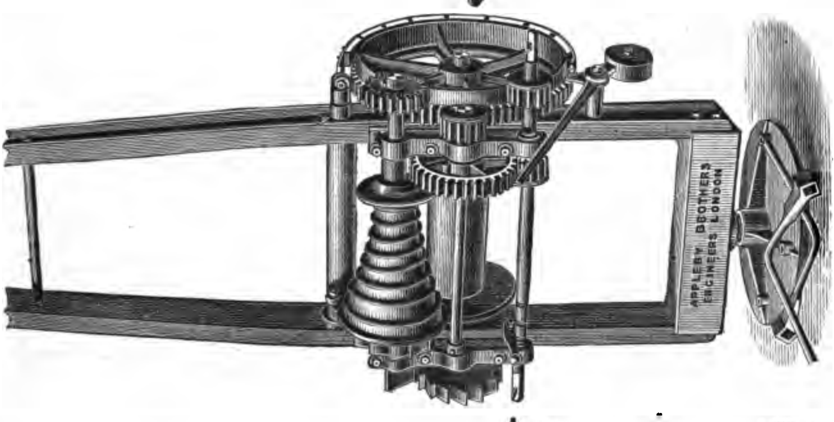


Fig. 140.

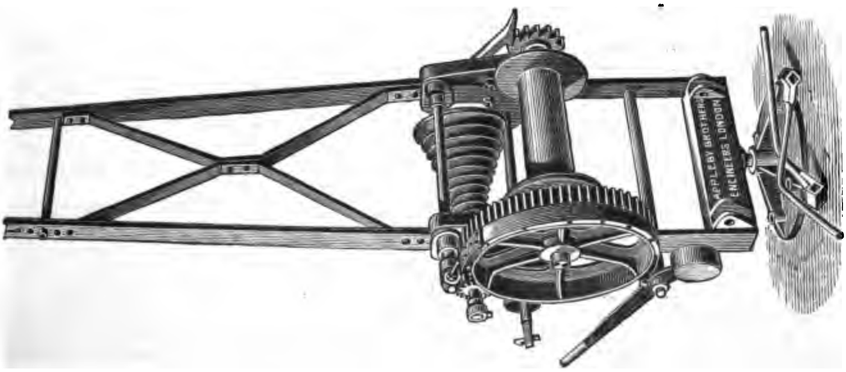


Fig. 139.

possess some advantages. The engravings are taken from photographs of cranes made for her Majesty's Government for use at Colombo Harbour. The crane, Fig. 139, is for ¾-ton, Fig. 140 for 1½-tons, and Fig. 141 for 3-tons loads, and the prices are given for both timber and iron. In some cases the ironwork, gear and chains are sent out ready to fit to timber provided at destination, which effects some saving in freight, and admits of the use of native timber. The price for a complete set of ironwork only averages 30 per cent. less than for the timber derrick complete.

For use on works requiring a considerable and variable radius of jib, great length of lift, moderate facility for removal and re-erection, together with a low first cost, no form of crane can compare with this. The jib will swing through 250° of the circle, and being hung on a pivot at the top and bottom, although the radius may be great, very little power is sufficient to turn the jib and load. All the sizes are fitted with single and double-purchase lifting gear, strap brake, ratchet and pawl, and safety derrick gear for altering the radius of the jib either with or without the load, and the derrick gear is so constructed that the load balances the tendency of the jib to run down; the load can therefore be moved horizontally to or from the centre of the crane with ease and safety after having been raised to any required height. The advantages of this will at once be apparent to anyone conversant with the work constantly recurring in quarries, stone yards, timber yards, buildings in progress, &c. Best memel or pitch pine are used for the timbers, and the centre mast is fitted with all gearing; the jib, backties and sleepers for same are fitted with the necessary ironwork, and chains are supplied to reach to ground line. If constructed of iron, the smallest size (¾-ton), the mast and jib are both made of flat wrought-iron bars braced together by diagonals, and for the larger sizes, channel irons of suitable section as shown are used for the mast and jib. The larger sizes can also be fitted with slewing or turning gear at the prices indicated.

Power of crane	1 ton	1 ton	1 ton	2 tons	2 tons	2 tons
Maximum radius of crane .	25 ft.	30 ft.	35 ft.	25 ft.	30 ft.	35 ft.
Price with timber frame ..	£47 0	£53 0	£58 0	£60 0	£64 10	£68 10
„ iron frame ..	£55 0	£60 0	£65 0	£70 0	£75 0	£80 0
Price extra for slewing gear	£5 0	£5 0	£5 0	£10 0	£10 0	£10 0
Approximate weight ..	3 tons	3¼ tons	3½ tons	3½ tons	3¾ tons	4 tons
„ measurement	150 c. ft.	180 c. ft.	200 c. ft.	200 c. ft.	220 c. ft.	240 c. ft.

Power of crane	3 tons	3 tons	3 tons	4 tons	4 tons	4 tons
Maximum radius of crane .	25 ft.	30 ft.	35 ft.	25 ft.	30 ft.	35 ft.
Price with timber frame ..	£80 0	£85 10	£92 10	£95 0	£102 10	£110 0
„ iron frame ..	£90 0	£100 0	£110 0	£120 0	£130 0	£140 0
Price extra for slewing gear	£13 0	£13 0	£13 0	£15 0	£15 0	£15 0
Approximate weight	4 tons	4½ tons	5 tons	5 tons	5½ tons	6 tons
„ measurement	240 c. ft.	280 c. ft.	300 c. ft.	300 c. ft.	350 c. ft.	400 c. ft.

Power of crane	6 tons	6 tons	6 tons	8 tons	8 tons
Maximum radius	25 ft.	30 ft.	35 ft.	25 ft.	30 ft.
Price with timber frame ..	£130 0	£140 0	£150 0	£160 0	£190 0
„ iron frame ..	£140 0	£150 0	£165 0	£175 0	£205 0
Price extra for slewing gear	£18 0	£18 0	£18 0	£20 0	£20 0
Approximate weight ..	6 tons	6½ tons	7 tons	7 tons	7½ tons
„ measurement	440 cub. ft.	460 cub. ft.	480 cub. ft.	500 cub. ft.	550 cub. ft.

Power of crane	8 tons	10 tons	10 tons	10 tons	
Maximum radius	35 ft.	25 ft.	30 ft.	35 ft.	
Price with timber frame ..	£200 0	£220 0	£235 0	£250 0	
„ iron frame ..	£220 0	£240 0	£255 0	£275 0	
Price extra for slewing gear	£20 0	£25 0	£25 0	£25 0	
Approximate weight ..	8 tons	9 tons	10 tons	11 tons	
„ measurement	600 cub. ft.	620 cub. ft.	660 cub. ft.	750 cub. ft.	

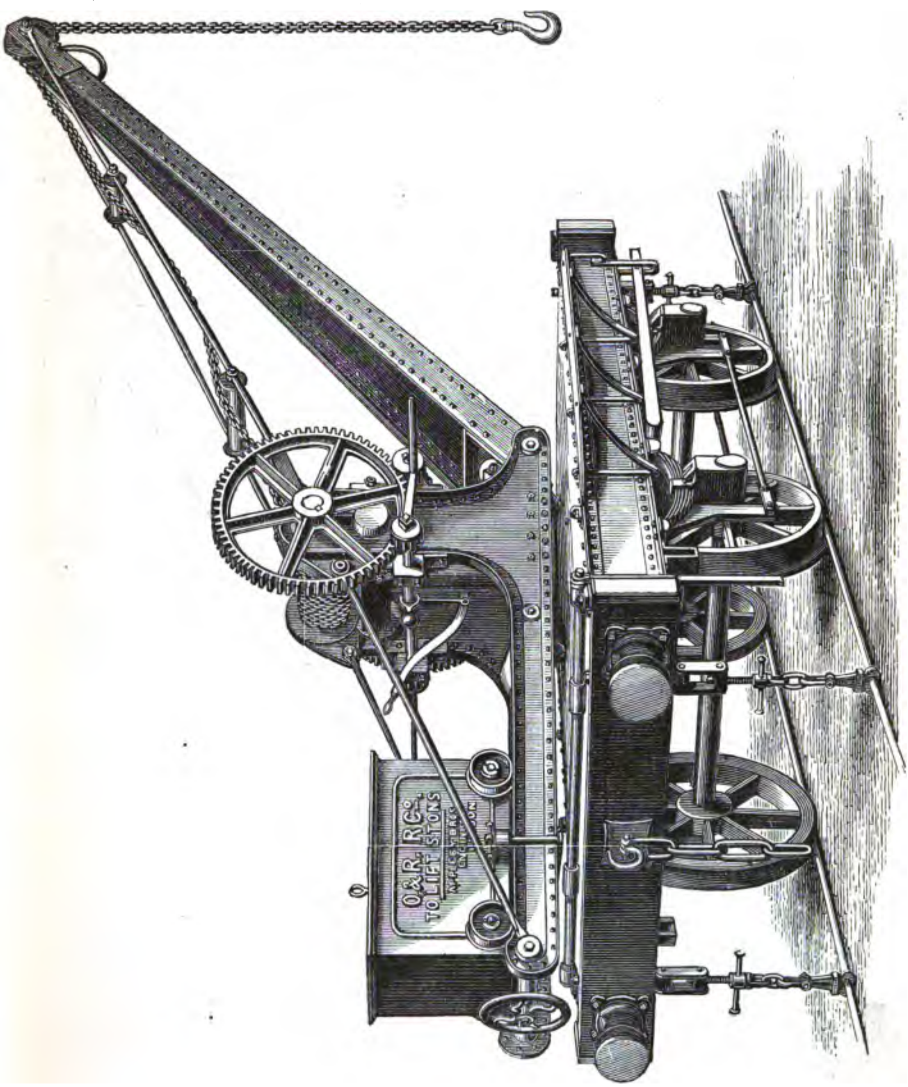


Fig. 142.

THE PORTABLE HAND-POWER CRANE, Fig. 142 (No. 7), illustrates a type of permanent-way crane constructed almost entirely of wrought iron, and largely used in India, Egypt, and other countries where timber does not stand well, and where great inconvenience is experienced if any breakage takes place. The engraving is from a photograph of cranes supplied to the Oude and Rohilkunde Railway, but cranes of the same design are used on the Soudan (3 ft. 6 in. gauge) Railway and many others.

The under carriages are fitted in all respects like the stock with which the cranes are intended to run; the wheels, axles, axle boxes, springs, buffers, couplings, draw springs, &c., being, where possible, the same as those in use by the company purchasing the cranes; so that in the event of any repairs or renewals being necessary, the company's stores will provide all that is required, a condition which will be duly appreciated by locomotive or carriage superintendents.

The construction and gearing do not vary greatly from the hand cranes, Figs. 127 and 128, the chief points of difference being that the side frames and jib are made of wrought-iron plates strengthened with angle irons rivetted up as shown, and the frames are fitted with wrought-iron tail pieces carrying a large wrought-iron balance box on wheels which can be run in or out from the centre of the crane to counterbalance the load: this box is moved by a screw and hand-wheel, and a clamping screw secures it to the tail pieces at any point; the tail pieces are fitted with a friction roller to carry the balance box when slewing without a load, and when travelling the weight of the balance box is taken below the tail pieces by a pair of cams on a cross shaft on the top of the under carriage; these cams also prevent the crane from turning, and at the same time relieve the post from vibration when running.

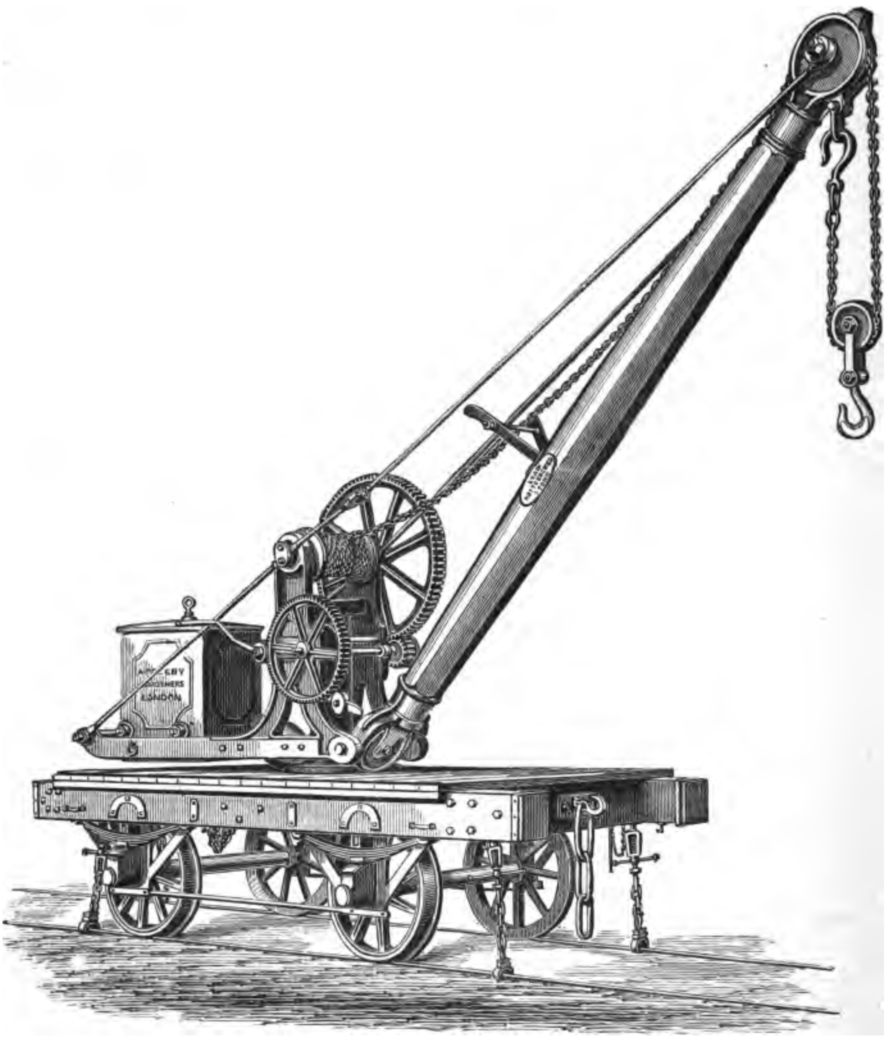


Fig. 143.

Ample platform space is provided for the men to work the crane at any angle across the carriage; this is sometimes obtained by using the hinged flaps shown in Figs. 142 and 144. Suitable provision is made for lowering the jib-head whilst travelling, and each crane is fitted

with a return block and chain of proper size and length to reach the ground line, also holding-down rail cramps, staples for cross girders, blockings for springs, and the carriage is fitted with an ordinary lever brake. The under carriages for 10-ton cranes have 6 wheels, and those for narrow-gauge metre (or 3 ft. 6 in. gauge) are fitted with sliding cross girders to give the necessary stability.

Many lines of railway have a permanent-way crane of about 10-tons power at each terminal station ready to send to any part of the system where it may be required for temporary service, or to clear the line after an accident or breakdown, and each crane has a "tender truck" fitted with all appliances usually required under such circumstances, such as sling chains, lifting jacks, crow-bars, picks, shovels, packings, planks, &c.; this truck also serves to carry the crane jib when it is laid down for travelling; but as these cranes and trucks are usually made to suit the special requirements of the officials of each railway they cannot be included in any general list of prices.

The crane, Fig. 143 (No. 2), is intended for the same duty as that above described, but is of cheaper construction, the side frames of the crane being of cast iron with wrought-iron tail pieces and cast-iron balance box; the under frame of the carriage and jib are of oak, and the spring buffers are omitted; it is however a good crane for ordinary work in ordinary climates, and for moderate powers. The prices, sizes, &c., of these cranes are given below.

The carriages are made for any gauge of railway or are fitted with flat-faced wheels for moving along a quay, and sometimes the smaller sizes have ordinary road wheels, locking fore carriage, and shafts for transport by horse-power over common roads.

PRICES OF PERMANENT-WAY PORTABLE HAND-POWER CRANES, Fig. 142 (No. 7).

Power of crane	3 tons	5 tons	10 tons
Radius of crane	12 ft.	13 ft.	14 ft.
Price complete	£260 0 0	£350 0 0	£550 0 0
Approximate weight	8 tons	12 tons	16 tons
" measurement..	300 cubic ft.	500 cubic ft.	600 cubic ft.

The above prices do not include balance weights, but these can be supplied at an extra cost of £10 per ton, the quantity required being about 2½, 4, and 8 tons respectively.

PRICES OF PERMANENT-WAY HAND-POWER CRANE, Fig. 143 (No. 2).

Power of crane	3 tons	5 tons	6 tons	10 tons
Radius of crane	12 ft.	13 ft.	13 ft.	14 ft.
Price complete	£185 0 0	£250 0 0	£265 0 0	£400 0 0
Approximate weight	8 tons	10 tons	11 tons	15 tons
" measurement ..	350 cubic ft.	500 cubic ft.	550 cubic ft.	600 cubic ft.

These prices do not include balance weights fitted in the boxes, for weight and cost of which see above.

PERMANENT-WAY CRANES WITH SELF-ACTING BALANCE, Fig. 144 (No. 6). All railway engineers will be familiar with the inconvenience, even on a line of 4 ft. 8½ in., arising from the careless manner in which the balance-weight box is used, and the narrower the gauge the greater is the risk of the balance box being too far from the centre and overturning the crane when the load is removed, probably pulling up the road and causing a loss of at least as much time as it was intended that the crane should save. It is therefore not surprising that so many inventors have directed their attention to this subject, and have taken out many patents to protect their inventions. The requisite conditions of great simplicity and certainty of action have, however, usually been somewhat neglected, and the patent self-acting balance permanent-way crane, Fig. 144 (No. 6), is the only arrangement which has come under the notice of the Authors combining the conditions above referred to and successfully accomplishing the objects sought to be attained.

The manner in which the load on the lifting chain acts on the counterbalance weights is shown so clearly in the engraving that little description will perhaps be necessary. The rigid rods which tie the jib-head to the side frames in Fig. 142 and all other cranes of that class, are here replaced by two short tie-rods, each with a chain-sheave at its lower end. One end of each of the chains passing over these sheaves is attached to a chain-barrel fitted with worm and wheel gear, whilst the other ends are coupled to the short arms of two bell-crank levers having a fulcrum in the top of the side frames; the lower ends of the long limbs of the bell-crank levers are fitted with weights connected by strong wrought-iron links to the axis of a cylindrical

balance weight, which is free to roll on the tail pieces of the crane framing. When the load is being lifted the strain due to the weight of the load passes through the tie bars and chains to the short arms of the bell-cranks, and the strain thus applied causes the long arms and weights to rise out of the vertical position and to draw the cylindrical weights into the position shown, or

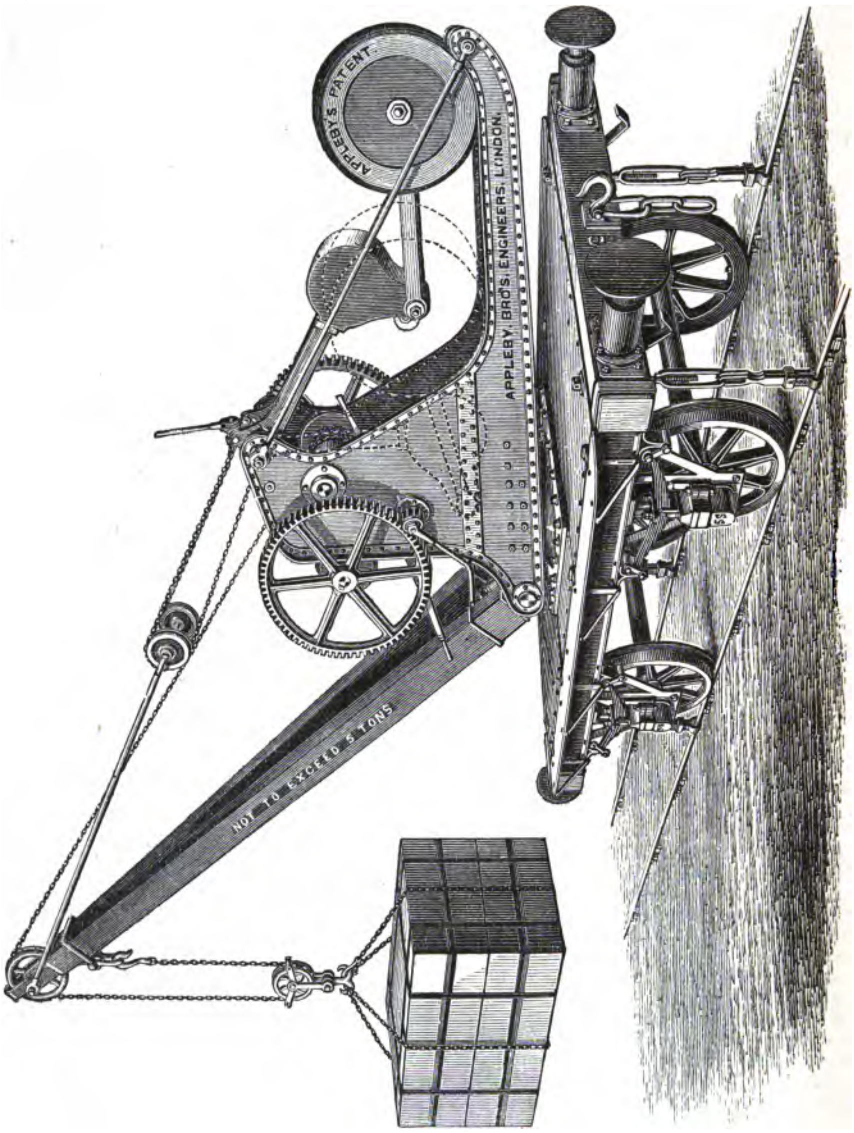


Fig. 144.

until they are at a distance from the centre sufficient to counterbalance the load being lifted. When the load is released the levers resume the vertical position shown in the dotted lines.

The action is therefore entirely automatic, there are so few parts, none of them liable to derangement, and all so strong and simple in construction that these cranes have never been known to fail in securing the safety and certainty which they were designed to afford.

The chain-barrel is fitted with a tangent wheel and worm which serves to adjust the jib to any angle or radius required, as well as to lower it down for travelling.

The under carriage and side frames are of wrought iron, and the speeds and powers of the gear and the general outfit is similar to the permanent-way crane, Fig. 142. The cost is, however, necessarily higher; but when regard is given to the cost of the balance weights, and the unquestionable advantage of the action of the counterbalance being automatic, the difference in price is not sufficient to preclude the use of this type of crane, especially on narrow-gauge railways, where for cranes of more than 3-tons power it is almost a necessity.

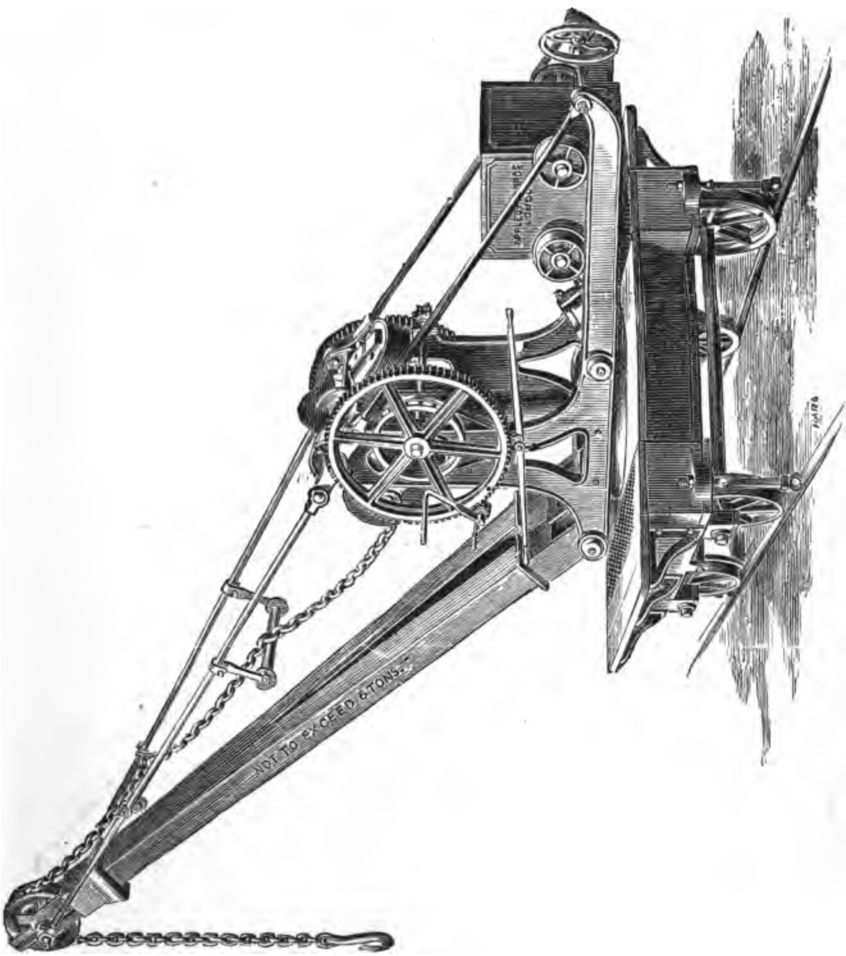


Fig. 145.

Prices of Permanent-way Self-acting Balance Cranes, Fig. 144.

Power of crane	3 tons	5 tons	10 tons
Radius of crane	12 ft.	13 ft.	14 ft.
Price complete	£360 0 0	£500 0 0	£700 0 0
Approximate weight	12 tons	17 tons	22 tons
„ measurement	350 cubic ft.	550 cubic ft.	700 cubic ft.

PORTABLE HAND CRANE, GOVERNMENT PATTERN, Fig. 145 (No. 1). These cranes are constructed to work loads varying from 3 to 10 tons, and can be adapted to work on any gauge of railway. They are used by Her Majesty's Government as well as by some of the leading railway and dock companies.

The base plate is in one massive casting, chequered on the top, and of sufficient size to allow the men to work at whatever angle the crane may be. The crane-post is of hammered iron; the journals are of great length, the shafts run in gun-metal bearings, and the working parts throughout are accurately fitted and carefully finished.

The balance-weight box is of ample size, and is moved along the tail-pieces by a traversing screw worked by a hand wheel. There is a friction-roller to take the weight off the back balance and reduce friction when turning. The engraving, Fig. 145, shows a 6-ton, and Fig. 146 a 3-ton crane.

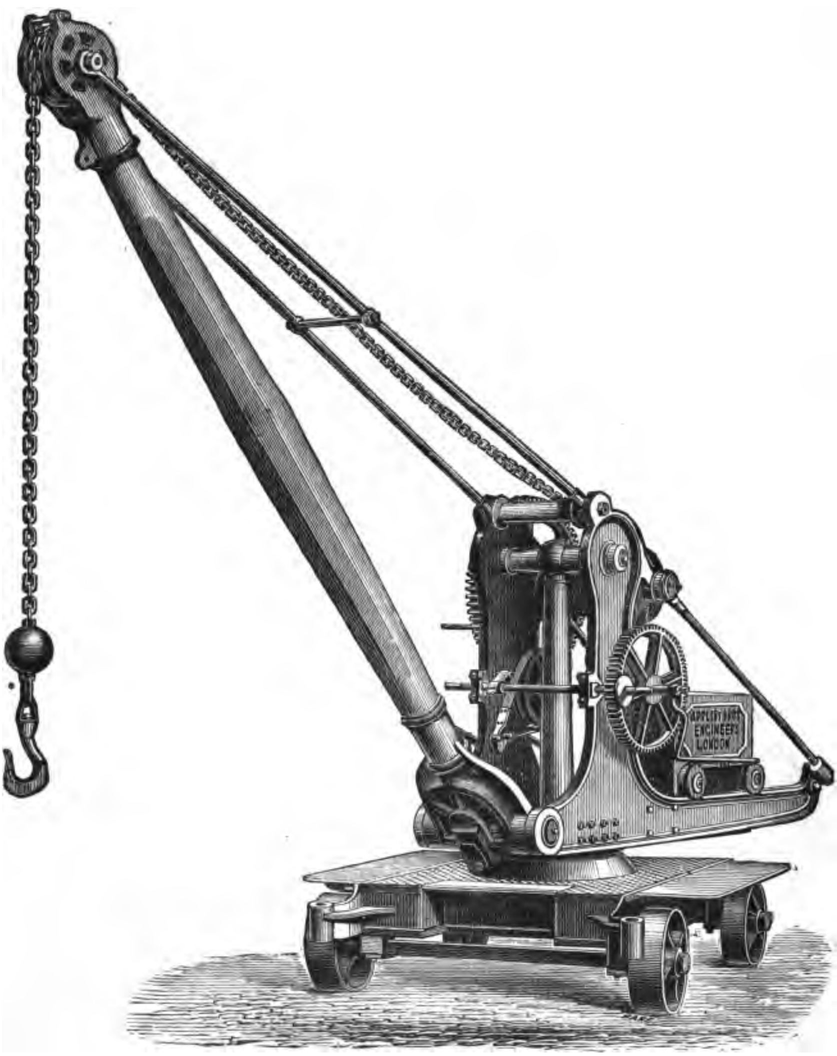


Fig. 146.

Power of crane	3 tons	5 tons	6 tons	10 tons
Radius of crane	12 ft.	13 ft.	14 ft.	14 ft.
Price complete	£165 0 0	£290 0 0	£350 0 0	£470 0 0
Approximate weight	4½ tons	9 tons	10 tons	13 tons
„ measurement ..	200 cubic ft.	300 cubic ft.	400 cubic ft.	600 cubic ft.

For cost of balance weight see p. 57.

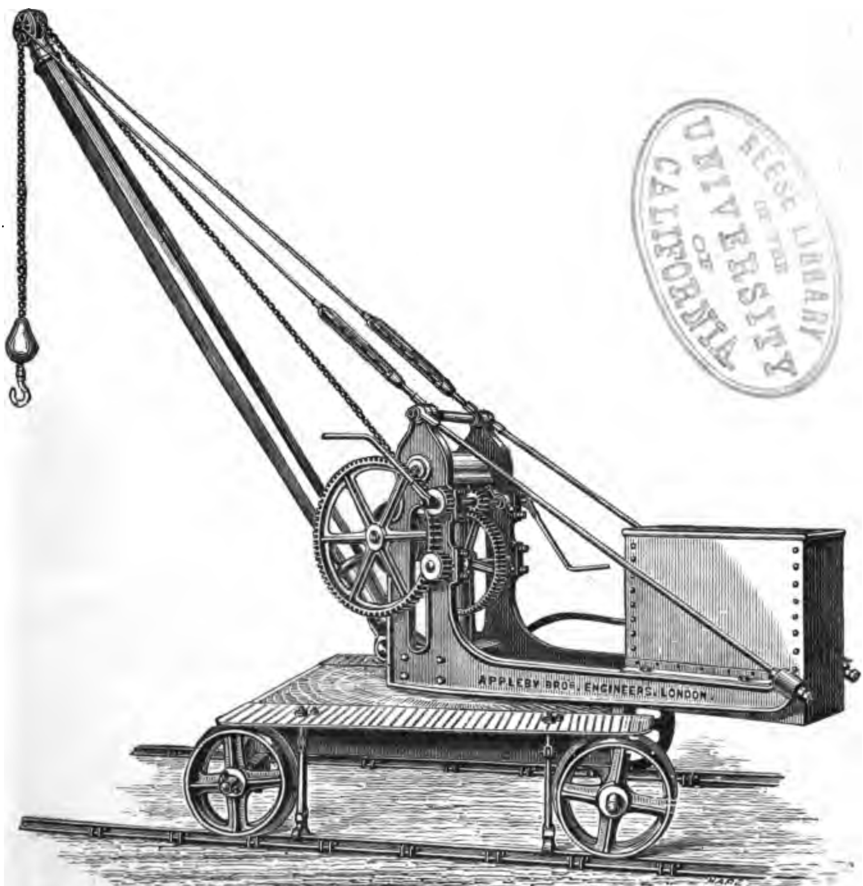


Fig. 147.

The cranes, Fig. 147 (No. 1B), and Fig. 148 (No. 4), are for lower powers than 3 tons, and are generally similar to the portable hand cranes before described, the chief difference being that they have not friction rollers, or a roller path on the bed plate, the whole weight of the revolving portion of the crane resting on the top of the central pillar which is of wrought iron. Fig. 147 is made in two sizes (1 and 2-tons), the prices being £110 and £125 respectively.

The cranes, Fig. 148, are made with plain or flanged wheels, and are lighter and cheaper than any of the foregoing; the vertical bars, tail-pieces, and tie bars are of flat wrought iron instead of the cast-iron side frames shown in Fig. 147. They are made of four sizes, ranging

from ½-ton to 2-tons, and each crane is fitted with chain of proper strength, and length sufficient to reach to the ground line.

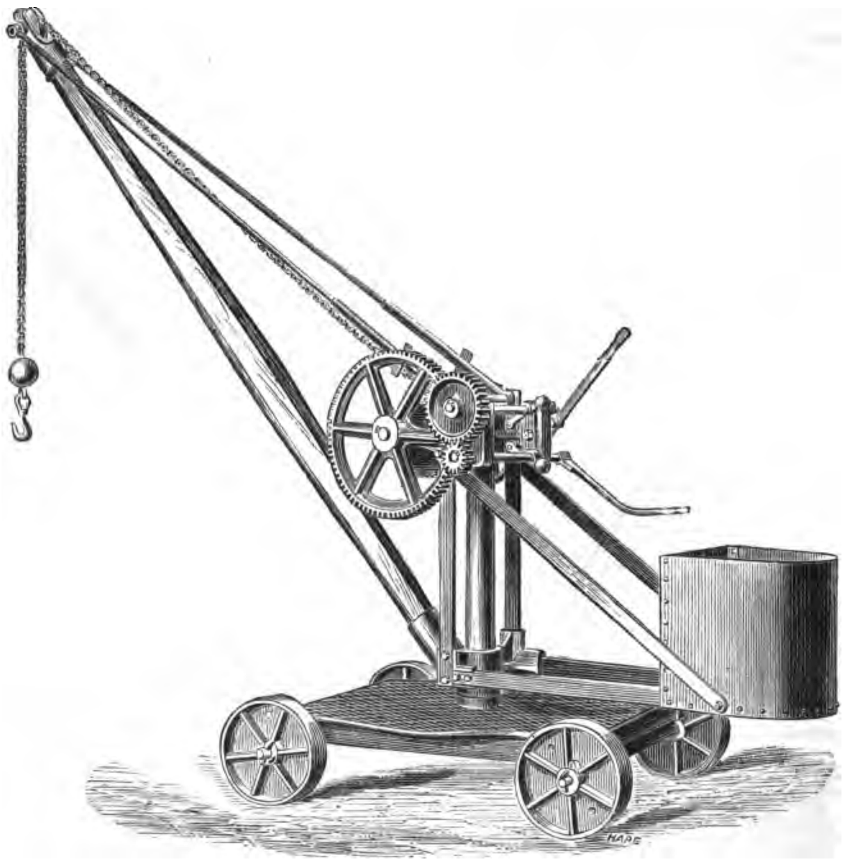


Fig. 148.

PRICE LIST OF No. 4 LIGHT PORTABLE HAND CRANES, Fig. 148.

Power of crane	½ ton	1 ton	1½ tons	2 tons
Radius of crane	10 ft.	10 ft.	10 ft.	10 ft.
Price	£40 0 0	£45 0 0	£50 0 0	£72 0 0
Approximate weight	1½ tons	1¾ tons	2 tons	3 tons
„ measurement ..	80 cubic ft.	100 cubic ft.	150 cubic ft.	200 cubic ft.

HAND PORTABLE CRANE, Fig. 149 (No. 5), is adapted for rough work or for shipment. The crane carriage, side frames, balance box, &c., being composed of wrought iron ; the jib and platform can also be made in wrought iron at a slightly increased cost. A number of these cranes have been constructed for Central America and the West Indies ; they are made of two sizes with plain or flanged wheels as desired, and each is fitted with chain, balance ball and hook, to reach the ground line.

Power of crane	3 tons	5 tons
Radius of crane	12 ft.	12 ft.
Price	£165 0 0	£235 0 0
Approximate weight	4½ tons	7 tons
" measurement	200 cubic ft.	300 cubic ft.

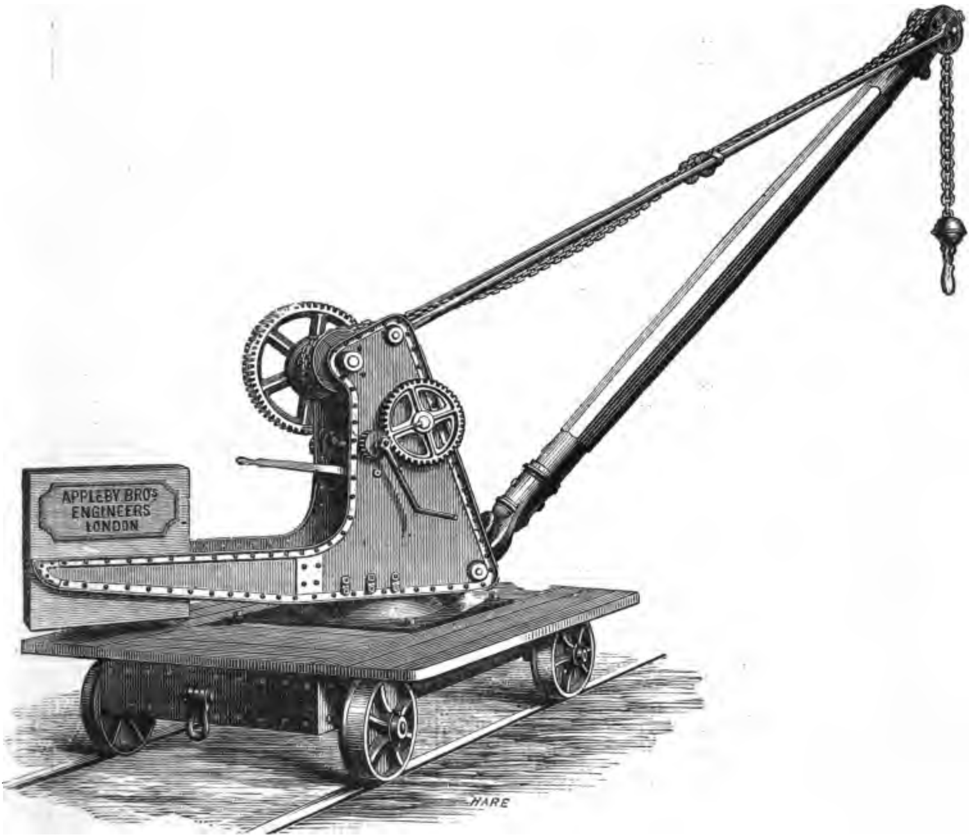


Fig. 149.

POWER OVERHEAD TRAVELLING CRANES. This class of machinery will be noticed in the following order, with a brief description of the construction and of the conditions under which each has been used.

1. Those with the engine and boiler moving with the load.
2. Travellers having the engine and boiler fixed at one end of the beams.
3. Travellers driven by a line of shafting.
4. Travellers driven by a high-speed cord.
5. Travellers driven by a slow-speed wire rope.

The engravings, Figs. 150 and 151, are good examples of the first-named type in which the engines and boiler move across the gantry with the load. The engraving, Fig. 150, is from a photograph of a traveller of 40-ft. span to carry a load of 6 tons, which was made by the Authors for the Midland Railway; the other, Fig. 151, is of 15-tons power and 50-ft. span, and was used in the construction of the Stack Rock Fort outside Pembroke Harbour. Travellers of a similar character, but varying in design to suit special conditions, have been used in carrying out the works of the Thames Embankment, the Municipal Buildings at Manchester, and many other public works at home and abroad; but the subjoined detailed description refers especially to Fig. 150, although it will apply generally to all.

Power of traveller	5 tons	6 tons	7 tons	8 tons
Span of traveller	40 ft.	40 ft.	40 ft.	40 ft.
Height of lift	20 ft.	20 ft.	20 ft.	20 ft.
Number, diameter, and stroke of cylinders	2—5″×9″	2—5″×9″	2—6″×10″	2—6″×10″
Diameter and height of boiler ..	2′ 9″×7′ 0″	2′ 9″×7′ 0″	3′ 0″×7′ 0″	3′ 0″×7′ 0″
Price complete with wood-trussed beams	£390 0 0	£410 0 0	£435 0 0	£455 0 0
Price extra per foot to 50-ft. span ..	£5 0 0	£6 0 0	£7 0 0	£8 0 0
Price with wrought-iron beams ..	£415 0 0	£425 0 0	£465 0 0	£515 0 0
Price extra per foot to 50-ft. span ..	£6 0 0	£7 0 0	£8 0 0	£9 0 0
Approximate weight	7 tons	8 tons	9 tons	10 tons
" measurement ..	300 cubic ft.	340 cubic ft.	380 cubic ft.	400 cubic ft.

Power of traveller	10 tons	15 tons	20 tons	25 tons
Span of traveller	40 ft.	40 ft.	40 ft.	40 ft.
Height of lift	20 ft.	20 ft.	20 ft.	20 ft.
Number, diameter, and stroke of cylinders	2—6″×10″	2—7″×10″	2—7″×10″	2—7″×10″
Diameter and height of boiler ..	3′ 0″×7′ 0″	3′ 6″×7′ 0″	3′ 6″×7′ 0″	3′ 6″×7′ 0″
Price complete with wood-trussed beams	£490 0 0	£550 0 0	£650 0 0	
Price extra per foot to 50-ft. span ..	£10 0 0	£11 0 0	£12 0 0	
Price with wrought-iron beams ..	£550 0 0	£600 0 0	£720 0 0	£850 0 0
Price extra per foot to 50-ft. span ..	£12 0 0	£13 0 0	£15 0 0	£20 0 0
Approximate weight	12 tons	17 tons	20 tons	23 tons
" measurement ..	500 cubic ft.	600 cubic ft.	650 cubic ft.	700 cubic ft.

Power of traveller	30 tons	40 tons	50 tons	
Span of traveller	40 ft.	40 ft.	40 ft.	
Height of lift	20 ft.	20 ft.	20 ft.	
Number, diameter, and stroke of cylinders	2—8″×10″	2—8″×10″	2—8″×10″	
Diameter and height of boiler ..	3′ 9″×7′ 6″	3′ 9″×7′ 6″	3′ 9″×7′ 6″	
Price complete with wood-trussed beams				
Price extra per foot to 50-ft. span ..				
Price with wrought-iron beams ..	£1000 0 0	£1250 0 0	£1500 0 0	
Price extra per foot to 50-ft. span ..	£25 0 0	£30 0 0	£35 0 0	
Approximate weight	26 tons	30 tons	35 tons	
" measurement ..	750 cubic ft.	900 cubic ft.	1100 cubic ft.	

The engines have two steam cylinders with link reversing motions, single and double purchase lifting gearing, powerful brake, and the blocks and chains are proportioned to the power of the traveller. The longitudinal and transverse travelling motions are both given by friction clutches, which can be put into motion in either direction without stopping or reversing the engines, and can be operated both together, and at the same time as the lifting or lowering motions are at work. The whole of the high-speed shafts are fitted with gun-metal bearings with loose

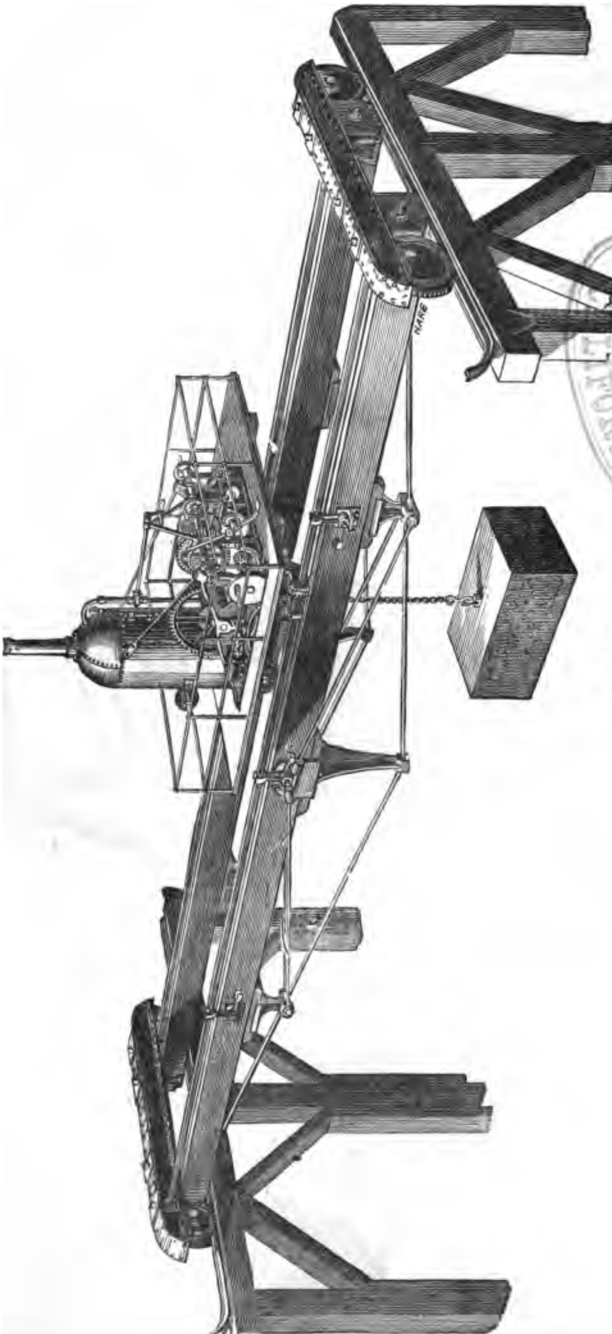


Fig. 150.

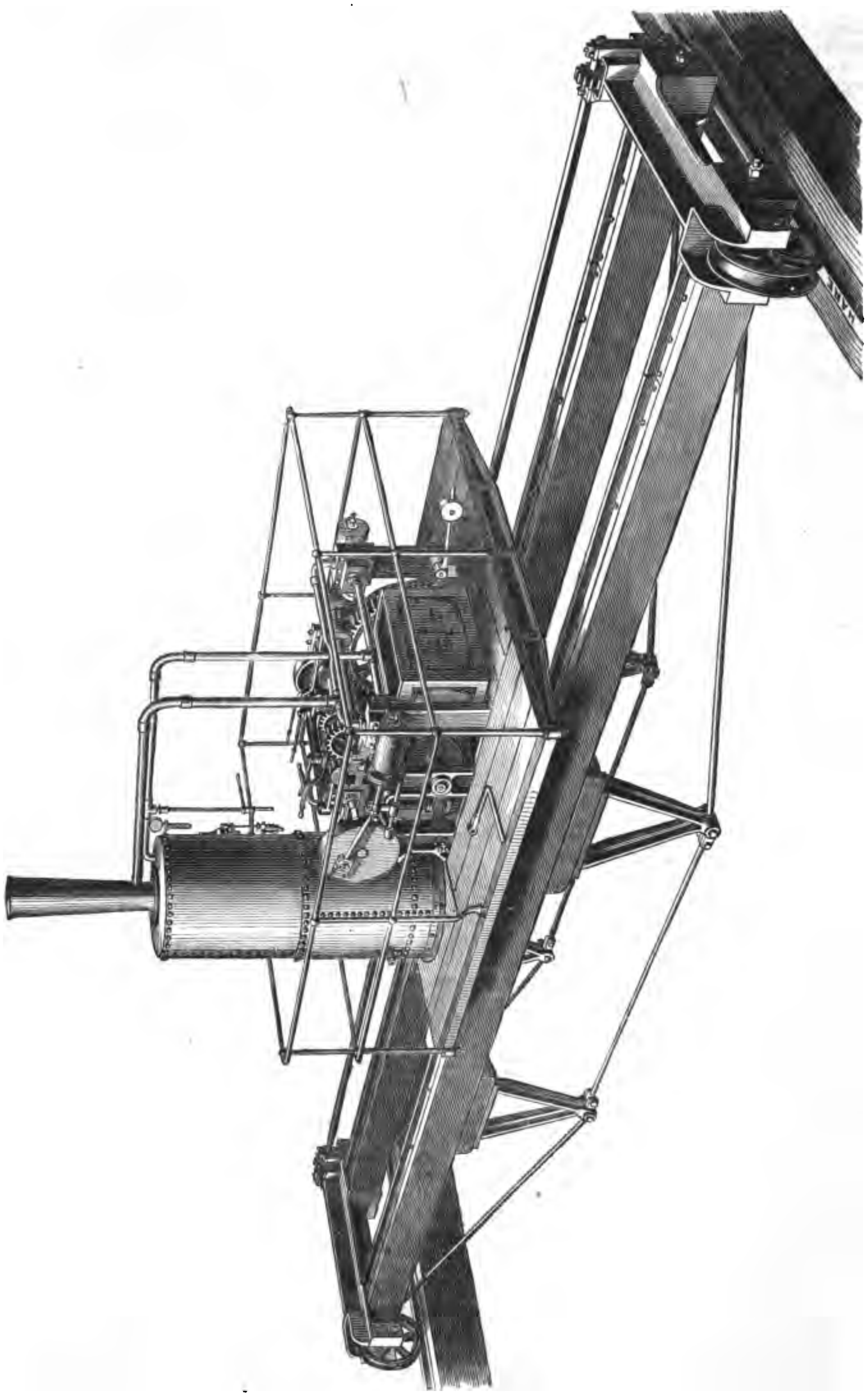


Fig. 151.

caps, where practical, so as to facilitate the removal of the shafts without the trouble of taking down the side frames. The boiler is of the vertical kind, and has cross water-tubes in the fire-box, or a number of 2½ diameter hanging water-tubes in the crown of the fire-box, whichever is preferred. The usual fittings consist of furnace bars, door, manhole and mudholes, with covers and bridges, chimney and damper, the ash pit being formed in the bottom of the boiler shell, safety-valve, steam-pressure gauge, water gauge, gauge cocks and blow-off cock, and a fusible plug in crown of furnace. The general quality of the plates is best Staffordshire; the crown plates, flue, and cross-tubes of Lowmoor or Bowling quality. Each boiler is tested with a pressure of 120 lbs. per square inch, and is of ample size to supply steam to the engines. The boilers of the larger travellers are mounted on a wrought-iron water tank, which also forms part of the foot-plate and platform; the smaller travellers have a tank as shown in Fig. 150. The whole of this portion of the traveller is mounted on a four-wheeled platform, two of the wheels being geared to give the transverse travelling motion to the crab and load, and the platform is fitted with a hand-rail and coal bunker.

The girders are of best pitch pine timber with wrought-iron truss rods, and cast-iron struts of suitable strength and depth; the ends of the girders are fitted with cast-iron shoes, with bosses to take the ends of the truss rods, and these shoes or caps are bolted up to the under sides of the end cradles. This arrangement has several advantages: it keeps the centre of gravity low, reduces the height required for head-room from rail level, and gives greater security, because in the event of any accident arising to the wheels, axles, or end cradles, the main beams can only fall about an inch; it also affords some facility in erection.

The girders or main beams are, however, frequently made of wrought iron of the fish-bellied form, composed of single web plates with angle irons and top and bottom table plates. The heaviest travellers have beams of the same form, but of a box girder section.

The end cradles are usually of cast iron of hollow box section, excepting for the heaviest travellers, when they are of wrought iron; in both cases they are fitted with double-flanged wheels, working loose on their axles, which are of great length and drilled up the centre for lubrication. The cradles or bogies for travellers above 25-tons power have 6 wheels.

The prices include the cost of chains and blocks of suitable strength and length for a lift of 20 ft. in height, but this height can be increased at a slight extra cost.

The cost of housings of corrugated iron is about the same as is quoted at page 21 for steam cranes of similar power.

OVERHEAD STEAM TRAVELLING CRANE, Fig. 152 (No. 1). The second type of overhead crane, which has the engine and boiler fixed at one end of the framing, is illustrated in Fig. 152; this construction has its own special advantages, some of which are that—

The weight of the engine and boiler are always directly over the point of support.

The main beams may therefore be lighter than would be required for travellers of the type, Fig. 150, as they do not have to carry the weight of the machinery in addition to that of the load.

The boiler being stationary (at one end), arrangements can frequently be made for getting rid of smoke when working in buildings or sheds.

The proportions of the engines, boilers, &c., for the corresponding weights and spans are the same as those given above.

Several travellers of this kind were used in the construction of the Cannon Street Bridge; they are also in use at the East and West India Dock timber sheds, working on a gantry which overhangs the dock wall, and are employed in taking timber direct from the ship's hold into the sheds where it is piled for sale. In those last mentioned, a motion is introduced which enables the traveller to transport itself from one line of shed to the next; and as a number of these sheds are parallel to each other, the power can thus be concentrated where it is most needed. A number of hand-power travellers are also used in these sheds in conjunction with the steam travellers, both running on the same gantries.

The logs are brought by the steam travellers from the ships to about the point where they are to be stored; and as the gantries are of great length, the high speed of working which is obtained by steam power is found to effect a great saving in time, together with a remarkable economy in cost as compared with hand labour. The hand travellers are used for sorting, piling, and delivering the logs; this being necessarily a slow process can be performed more economically by manual labour than by steam power.

This system of working has been adopted by Mr. A. Manning, the engineer to the East and West India Docks; and, having regard to the varied character of the work to be performed, it is difficult to conceive any arrangement which would effect so large a saving in time, space, and cost of working. The same remark may, however, be made with reference to many other highly successful arrangements for saving time and labour devised by Mr. Manning, the mechanical portions of some of which have been carried out by the Authors.

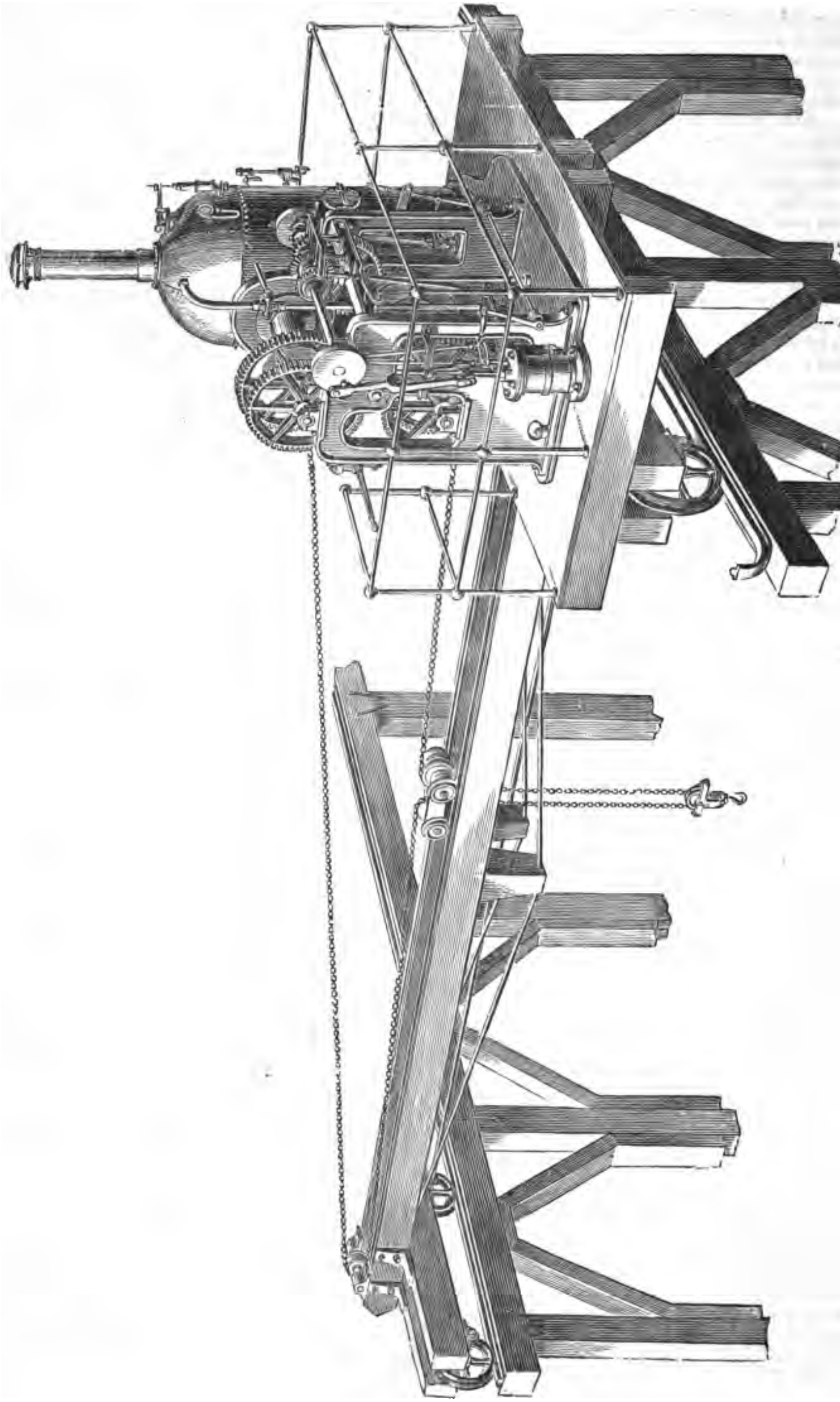


Fig. 152.

OVERHEAD TRAVELLERS DRIVEN BY A LINE OF SHAFT, Fig. 153. These come under the third head, and are well adapted for use in foundries, erecting-shops, saw mills, and in other buildings where there is motive power available for driving a tumbler shaft, and where the length to be traversed longitudinally does not exceed 200 to 300 ft.; beyond this length the torsion of the tumbler shaft becomes objectionable.

Fig. 153 illustrates a traveller to carry a load of 50 tons, with a span of 45 ft., designed and constructed by the Authors for the North Eastern Marine Engineering Company, for use in their works at Sunderland, and is perhaps the most powerful traveller of this type which has hitherto been made.

The main beams are wrought-iron fish-bellied box girders, the end cradles are also of box section fitted with 6 steel double-flanged wheels, working on fixed axles lubricated through the centre, the great weight on each wheel rendering the use of steel necessary; the four crab wheels are also of steel. These could not have fixed axles, but are provided with double frames or journals. The crab is fitted with single, double, and treble purchases, which are changed by a hand wheel and screw; the barrel is spirally grooved to take the full length of chain without an overlap, and is geared directly on the barrel at each end, so that there is no torsional strain on the barrel shaft or barrel. The top and bottom blocks are fitted with three sheaves, thus giving seven laps of chain.

In addition to the three speeds of lifting gear there is a set of geared change wheels and clutches on the first motion shaft, so that by a single movement *the whole of the lifting and travelling speeds* are altered in the ratio of 2 to 1, thus giving lifting speeds of six powers without altering the chain blocks, and two speeds of longitudinal and cross travelling, and converting what would otherwise be a slow, ungainly tool, into one very generally useful; the maximum load of 50 tons being of course rather exceptional.

All the motions are given by large copper-lined reversing friction clutches, and the brake and pawl are connected and worked by a foot lever, the pawl being lifted out of gear when the brake is applied. All motions of lifting and travelling can be worked simultaneously; and the levers are brought together and are worked by one man, at a point where he can observe every movement without obstruction, a matter of great importance when (as in all travellers of this kind) the attendant must work entirely by signs, and any mistake might cause damage to a costly piece of machinery. All the motions can be worked by hand power if desired. On the first trial with a load of 51 tons, the deflection of the whole including that of the longitudinal beam was noted and found to be less than ⅜ of an inch, and none of this was a permanent set.

The longitudinal shaft, from which all the motions are taken, is of 3″ square iron driven at 100 revolutions per minute, and the tumbler bearings are adjustable, so that in the event of any settlement taking place in the supports, the shaft can be easily lined up. One or more travellers of any power may be driven from the same shaft, and in the works above referred to they are used from 5 tons to 50 tons.

The prices are given for all sizes within those limits, and 40-ft. span is taken as a standard.

PRICE LIST OF POWER TRAVELLERS DRIVEN BY TUMBLER SHAFTS.

Power of traveller	5 tons	6 tons	7 tons	8 tons	10 tons
Span of traveller	40 ft.	40 ft.	40 ft.	40 ft.	40 ft.
Height of lift	20 ft.	20 ft.	20 ft.	20 ft.	20 ft.
Price with wood beams	£250 0	£260 0	£270 0	£280 0	£300 0
Price per foot extra to 50 ft. ..	£5 0	£6 0	£7 0	£8 0	£10 0
Price with wrought-iron beams..	£275 0	£285 0	£300 0	£340 0	£380 0
Price per foot extra to 50 ft. ..	£6 0	£7 0	£8 0	£9 0	£12 0
Approximate weight	5 tons	6 tons	7 tons	8 tons	9 tons
„ measurement ..	200 cub ft.	240 cub. ft.	270 cub. ft.	300 cub. ft.	360 cub. ft.

Power of traveller	15 tons	20 tons	25 tons	30 tons	40 tons	50 tons
Span of traveller	40 ft.	40 ft.	40 ft.	40 ft.	40 ft.	40 ft.
Height of lift	20 ft.	20 ft.	20 ft.	20 ft.	20 ft.	20 ft.
Price with wood beams ..	£400 0	£500 0				
Price per foot extra to 50 ft...	£11 0	£12 0				
Price with wrought-iron beams	£450 0	£550 0	£700 0	£800 0	£1000 0	£1200 0
Price per foot extra to 50 ft...	£13 0	£15 0	£20 0	£25 0	£30 0	£35 0
Approximate weight.. ..	14 tons	17 tons	20 tons	23 tons	26 tons	30 tons
„ measurement ..	450 c. ft.	550 c. ft.	600 c. ft.	650 c. ft.	750 c. ft.	900 c. ft.

This class of traveller is exceedingly useful in boiler shops and girder yards, for bringing the work to and from the hydraulic or steam rivetters.

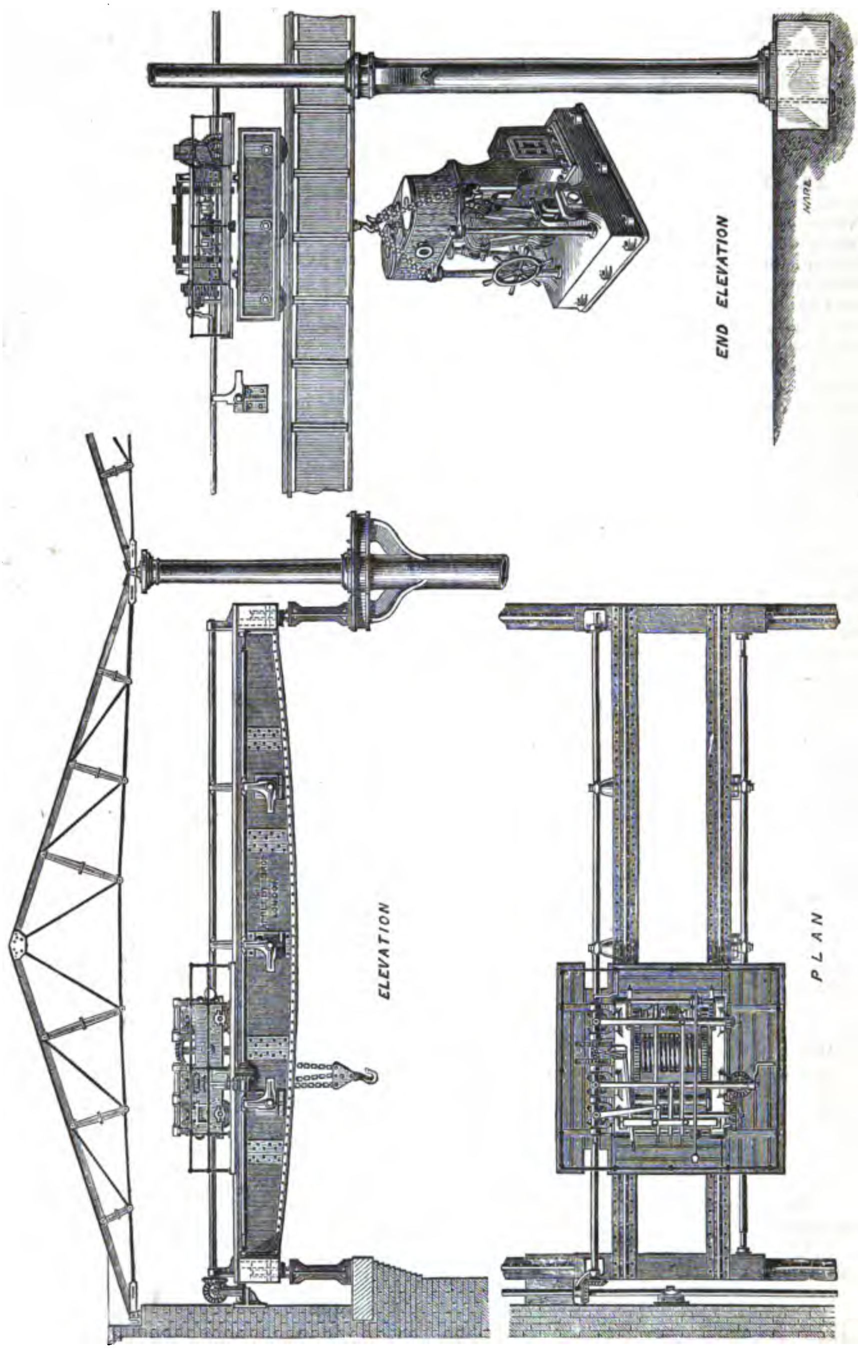


Fig. 153.

The height of lift is assumed to be 20-ft. nett lift, and each traveller is complete with chains, blocks, and hand motions.

The designs will necessarily vary to some extent with each size, but the variations will be mainly in the proportions.

The prices include the bevelled wheels for the tumbler shaft, but not any shafting, with bearings; this is worth from £1 10s. to £2 per cwt.

TRAVELLERS DRIVEN BY HIGH-SPEED OR "FLYING" ROPE, Fig. 154. The power is transmitted from a cotton cord of ½ in. to ⅝ in. diameter running at a speed of about 5000 ft. per minute, the strain on the cord exclusive of friction being about 28 lbs. when the traveller is doing its maximum work. Prominent amongst the advantages this system offers is the facility with which power is transmitted obliquely, or in any direction without noise and to almost any distance required, without the intervention of shafting and bevil gear with the substantial supports necessary for them, whilst the rope is carried on a brass shoe or light brass sheave, and can be arranged to work several travellers or single-rail cranes of the type referred to at p.

Many good examples may be seen in constant work in locomotive and erecting-shops where they have been in operation for many years (at the London and North Western Locomotive works at Crewe for nearly 20 years), but the cranes selected for illustration were designed and constructed by the Authors for the new railway carriage works recently erected by the Midland Railway Company at Derby. These travellers have a span of 50 ft., and lift 3 tons at quick speed and 5 tons at the slow speed, and have all improvements recently made in this class of machinery. The main beams are of wrought iron, and the end cradles, which are fitted with wheels to give the longitudinal travelling motion, are of cast iron of hollow box section. There is a third light beam the same span as the main beams, which adds stiffness to the structure and serves to carry a platform of light open cast-iron grating, through which the attendant can always see the exact position of the load as he walks alongside the crab.

The high speed of the cord pulleys is reduced and the necessary power is gained primarily by worm and tangent wheel gearing. The cord pulley for giving the lifting motion has cones of two or more diameters; these are caused to revolve by the cord being brought into contact with one or other of them by a hand lever fitted with carrying sheaves, and thus different speeds and powers of lifting are obtained. The reversing motion (for lowering the load) is obtained by simply passing the cord to the opposite side of the cone.

The travelling motions are obtained in a somewhat different manner: a pair of discs, about 6 ft. apart, slide on the spindle from which these motions are taken, and another disc made of papier maché or leather, slightly less in diameter than the distance between the two discs, is keyed on the worm shaft, which has its axis at right angles with the spindle above referred to; the discs are fitted with a suitable hand lever, and the reversing motion in travelling is produced by one or other of them being brought into contact with the papier maché disc.

All the worm wheels can be thrown out of gear, and shafts and handles are provided for working any motion by hand power if desired.

For lifting locomotives it is found very convenient to have two crabs on one travelling gantry, because each crab is brought directly over each buffer beam, which divides the strain on the crabs and gives a more even distribution of load on the gantry; one crab may be thrown out of gear and the other used for ordinary work. This arrangement is also adopted for hand travellers with much advantage, see pages 73 and 74.

Power of traveller	5 tons	10 tons	20 tons	30 tons	40 tons
Span of traveller	40 ft.	40 ft.	40 ft.	40 ft.	40 ft.
Price of traveller	£350 0	£450 0	£650 0	£900 0	£1200 0
Approximate weight	5 tons	10 tons	16 tons	22 tons	26 tons
„ measurement ..	200 cub. ft.	350 cub. ft.	500 cub. ft.	600 cub. ft.	700 cub. ft.

The prices include chains for 20-ft. lift, but do not include any of the driving arrangement necessary for the cord.

The cost per foot extra for longer spans will be the same as for steam-power travellers, page 64.

TRAVELLERS DRIVEN BY SLOW-SPEED WIRE ROPE. The chief difference between these and the "flying rope" travellers last described, is that instead of a high-speed cotton

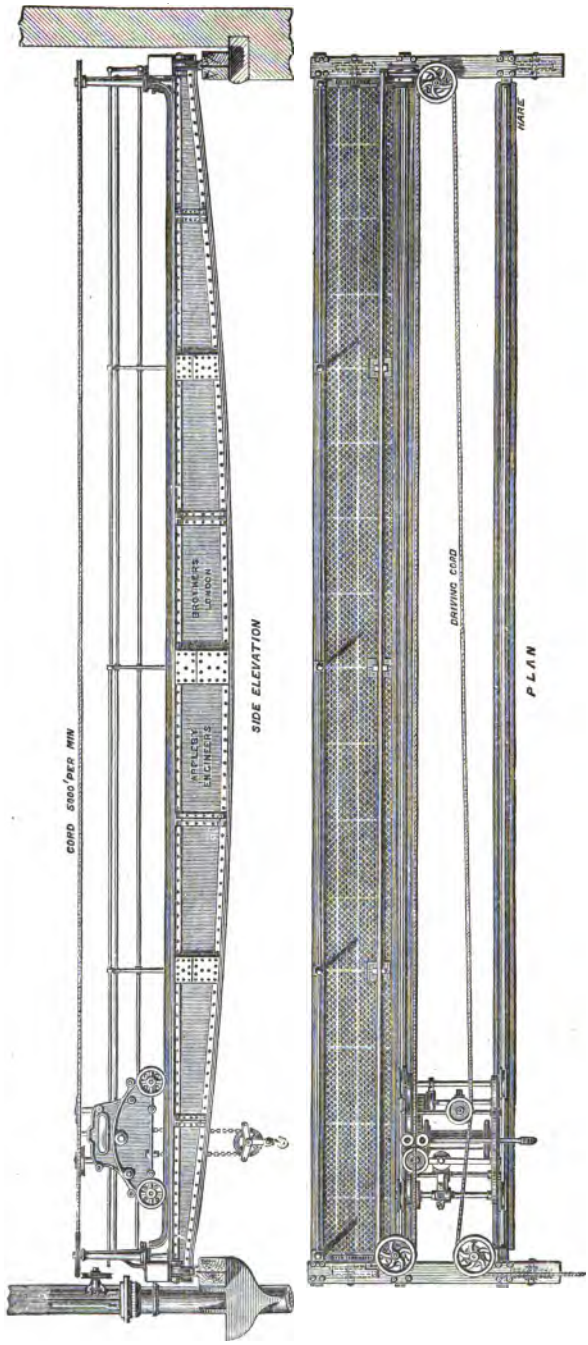

CORD 5000' PER MIN
APPLEBY ENGINEERS
BROTHERS LONDON
SIDE ELEVATION
DRIVING CORD
PLAN

Fig. 154.

cord, a steel wire rope about ⅝ in. diameter is used; the speed at which the rope travels is 300 to 350 ft. per minute, and the pull on it is about 300 lbs. This involves the use of twin drums or Fowler's patent clip drum, illustrated and described at p. 121, by which the necessary bite or adhesion of the rope to the driving pulleys is obtained without much wear and tear; another point of difference is, that at the relatively low speed of 300 ft. per minute for the primary motor, spur gear can be used instead of worm and wheel gear.

This system has not hitherto been so largely adopted as that last described, and there are instances where it has been abandoned. This however is due to some defect in design or construction, and not to the system itself; it has given very excellent working results wherever it has been properly carried out. The prices for travellers of this construction for a given weight and span are practically the same as are given at page 71 for the cotton-cord travellers.

HAND-POWER OVERHEAD TRAVELLERS WORKED FROM ABOVE. The attention of the Authors has for many years past been specially directed to the design and construction of these most useful machines, which are now becoming so largely used for saving labour and economising space in crowded yards, factories, warehouses, &c. Contrary to the general practice, they have endeavoured to obtain the maximum of strength with a minimum total weight, together with a high class of workmanship in the moving parts. Many people think that "anything is good enough for a hand traveller," but the remarks made at page 38 with reference to the necessity of good work in hand-power cranes apply with even greater force to travellers, because the total weight of the traveller, with the load suspended, has to be put in motion every time it is used. The *speed* at which the travelling motions can be worked by manual power is also an important element in the ultimate economy to be obtained; it should be as high as can be worked with a given load, and a slight error in design or an equally slight defect in workmanship may (and often does) involve the necessity of employing two men when one ought to suffice. The extra cost of labour will thus amount to probably not less than £50 per annum, whereas the interest on the difference in cost between a well and an ill made traveller would not be more than from £2 to £5 per annum; to this may be added the loss, in time, from slow working continually incurred when a number of hands are waiting for any of the various operations which the traveller performs.

Great care should be taken that the rails on which the traveller is to run are perfectly in gauge, and the joints fished or have a plate under each joint; these points rarely receive sufficient attention. The Authors' practice is to have the travelling wheels turned truly on their faces and flanges, the bearings brass-bushed, and good provision made for lubrication; the geared wheels are carefully set out, and are clean castings. In the designs referred to in the following pages, each motion is as direct as possible consistently with handiness in working; special regard is given to this in arranging the longitudinal travelling motion which is taken from the crab and is therefore necessarily somewhat indirect, but the total number of wheels and pinions is only 8; it is however not unusual to see 16 wheels (with their corresponding shafts and bearings and the friction attendant on them) to obtain this motion. Separate handles are provided for lifting and for travelling longitudinally and transversely, so that each motion is independent of the other, and any of them can be worked in either direction without changing clutches or handles and without shipping a shaft; the value of these facilities for working in an erecting-shop, or when piling timber or goods, must be seen to be fully appreciated.

The traveller, Fig. 155 (No. 13), is used for lifting locomotives weighing 30 tons, and each of the two crabs will lift 15 tons when worked by four men, one crab lifting at each buffer beam. The traveller girders are fish-bellied, of wrought iron, with a single web and top and bottom tables; the top member has a heavy rail of bridge section rivetted through the plate and angle irons. There is a lattice girder of similar form, but with lighter angle irons and top and bottom flanges, on the outside of each of the main girders, and these with the open cast-iron gratings which form the foot plate give great lateral stiffness to the main beams.

The girders are attached by bolts to the underside of the cast-iron end cradles which are of hollow box section; the travelling wheels are between the main and platform girders; the wheels have brass bushes of great length, which work on fixed axles and are fitted with oil cups for lubrication.

The general arrangement of the crab gearing is distinctly shown in the enlarged view, Fig. 159; it will therefore be unnecessary to describe it closely in detail. The lifting gear is single and double purchase, and the power is increased by blocks and chains, the upper sheaves for which are carried in the transome on the top of the side frames of the crab. The chain barrel is keyed into the large spur wheel to relieve the shaft from torsion, the ratchet wheel is cast to the flange of the barrel, and the brake ring is cast to the spur wheel; the brake strap is lined with wood and fitted with a hand lever. It will be seen that the two travelling motions are on one centre; the longitudinal motion being the heaviest work, is given by the crank handle; the lighter work of the transverse motion is given by the hand wheel, and as the attendant can

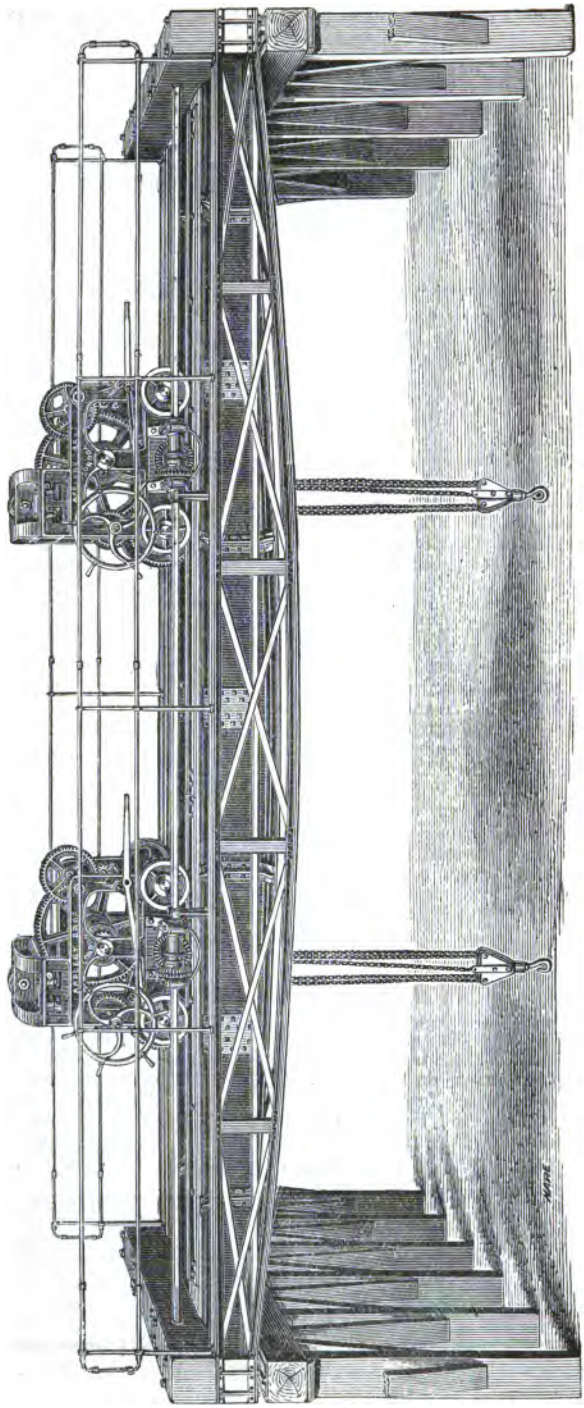


Fig. 155.

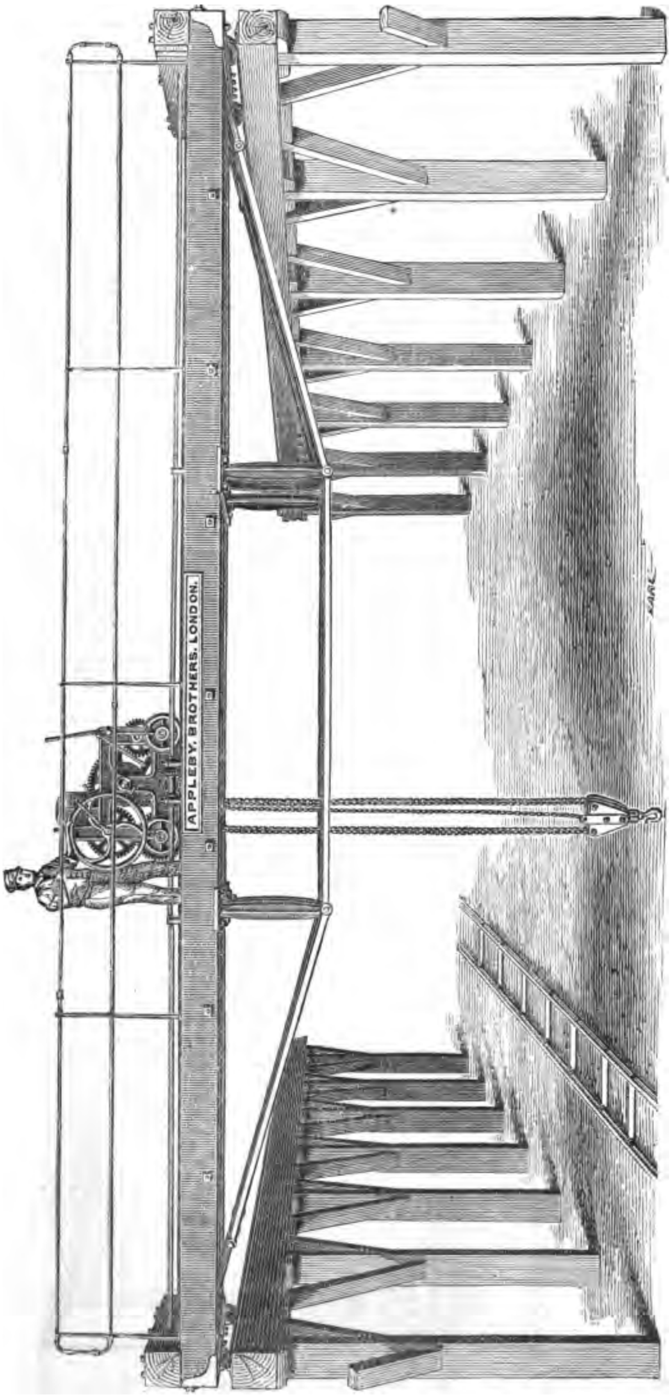


Fig. 156.

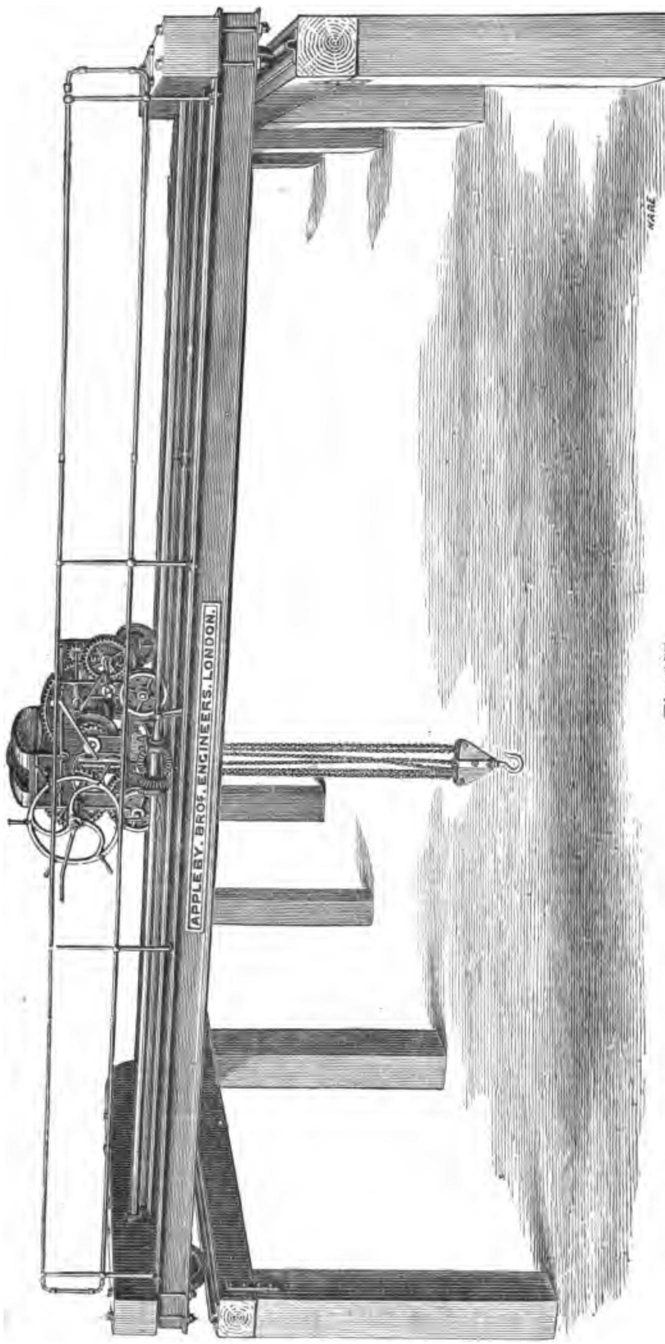


Fig. 157.

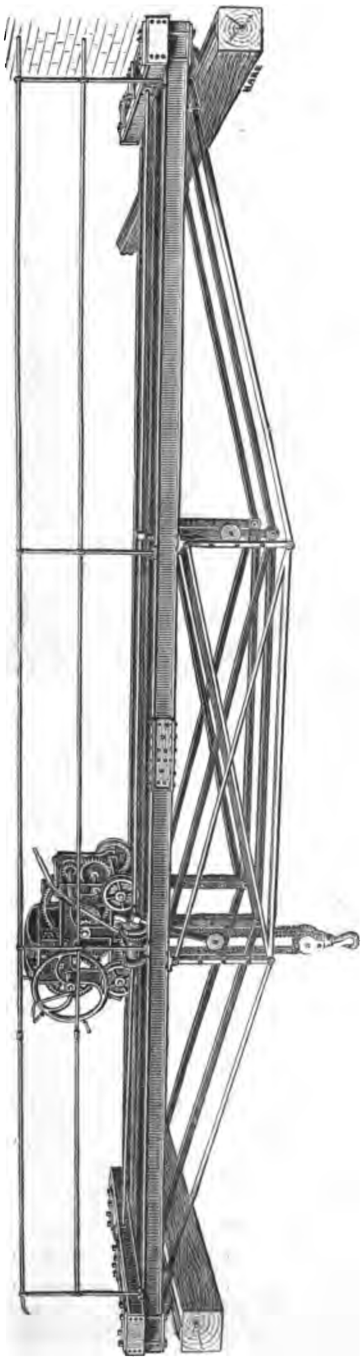


Fig. 158.

have one hand on it and the other on the crank handle, a load can be simultaneously moved transversely and longitudinally any short distance required, a condition most favourable to such operations as setting stones, erecting machinery, &c.

The advantages afforded by this arrangement of two crabs are, that when the maximum load is being lifted it is distributed between two sets of chains and gear, and over a great portion of the main beams; the men are not unduly crowded, and each can apply his force with proper effect; the load can also be lifted level or be canted to any position required, or for light work one crab can be thrown out of gear and run to one end, and all the motions performed by the other. Travellers for loads of less than 20 tons are rarely made with two crabs, but the types shown in Figs. 156 to 158 can be so fitted if desired, or the heavier class can be made with a single crab equal to dealing with the maximum load if (as sometimes happens) the use of two crabs is inadmissible.

It will also be noticed in the Engravings above referred to that various forms of girders are used—Fig. 156 (No. 11) having timber beams and double struts and truss rods: this sort of trussing is used for 40-ft. span, below 30 ft. a single strut, and above 40 ft. a treble strut, the timber platform beam in each case being of exactly the same form as the main beam, but much lighter; and when timber beams are used the platform is made of open battens, unless cast-iron open foot-plates are specially desired. In Fig. 157 (No. 12) the beams are of wrought-iron rolled H section, with a bridge rail rivetted on the top flange, and in some cases the girders are strengthened by a top and bottom plate rivetted to the flanges. This construction is adopted for travellers with wrought-iron beams up to 10 tons for 20-ft. span, and for 5 and 6 tons up to 30-ft. span. It has the advantage of giving the maximum amount of head room in a minimum of total height.

Fig. 158 (No. 9) shows the main and platform girder of wrought iron, rolled H section and trussed; this construction is adopted for light travellers of long spans, where wrought-iron beams of light appearance are required.

The general construction of end cradles, crabs, &c., is the same in all, differing only in proportion.

The cost of a complete set of ironwork and chains is about 30 per cent. less than for the traveller complete with trussed timber beams.

The following prices include the chains and blocks for the nett lift as given above; if a shorter span is required, the cost per foot does not decrease in the same ratio as the span decreases.

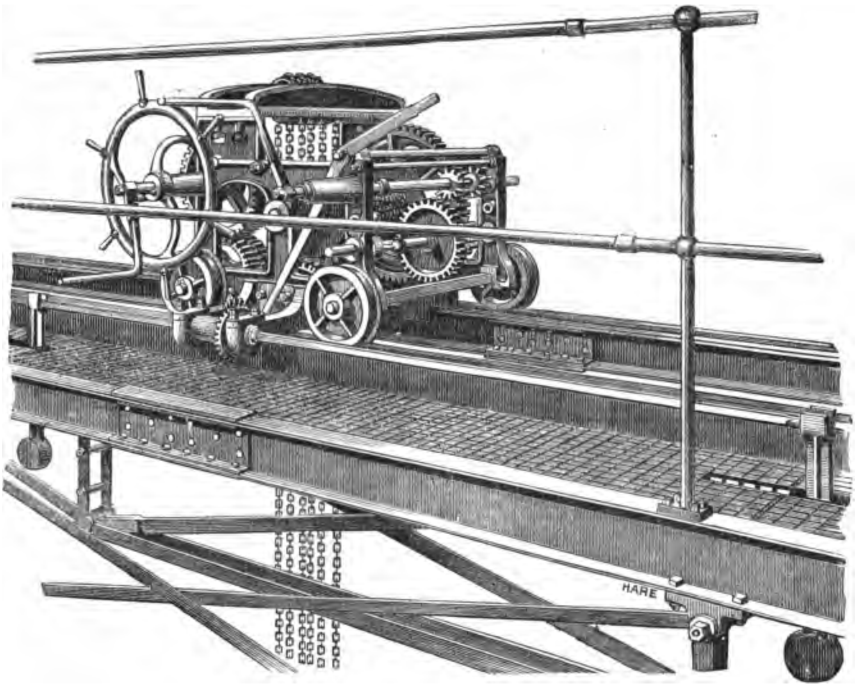


Fig. 159

Power of traveller	3 tons	4 tons	5 tons	10 tons	15 tons
Span of traveller	40 ft.	40 ft.	40 ft.	40 ft.	40 ft.
Height of lift	15 ft.	15 ft.	15 ft.	15 ft.	15 ft.
Price of traveller with *one* crab and one platform, and timber-trussed beams	£120 0	£150 0	£170 0	£210 0	£300 0
Price per foot extra span to 50 ft.	£3 0	£4 0	£5 0	£10 0	£11 0
Price as above with wrought-iron beams	£135 0	£170 0	£200 0	£250 0	£350 0
Price per foot extra span to 50 ft.	£3 10	£4 10	£6 0	£12 0	£15 0
Approximate weight	4 tons	4½ tons	5 tons	8 tons	12 tons
„ measurement ..	170 cub. ft.	180 cub. ft.	200 cub. ft.	300 cub. ft.	430 cub. ft.

Power of traveller	20 tons	25 tons	30 tons	40 tons	50 tons
Span of traveller	40 ft.	40 ft.	40 ft.	40 ft.	40 ft.
Height of lift	20 ft.	20 ft.	20 ft.	20 ft.	20 ft.
Price of the traveller with *one* or *two* crabs, two platforms, and wood-trussed beams	£380 0	£460 0	£550 0		
Price per foot extra span to 50 ft.	£12 0	£15 0	£18 0		
Price as above with wrought-iron beams	£440 0	£530 0	£650 0	£750 0	£850 0
Price per foot extra span to 50 ft.	£17 0	£20 0	£23 0	£26 0	£30 0
Approximate weight	14 tons	17 tons	20 tons	23 tons	26 tons
„ measurement ..	450 cub. ft.	550 cub. ft.	600 cub. ft.	650 cub. ft.	750 cub. ft.

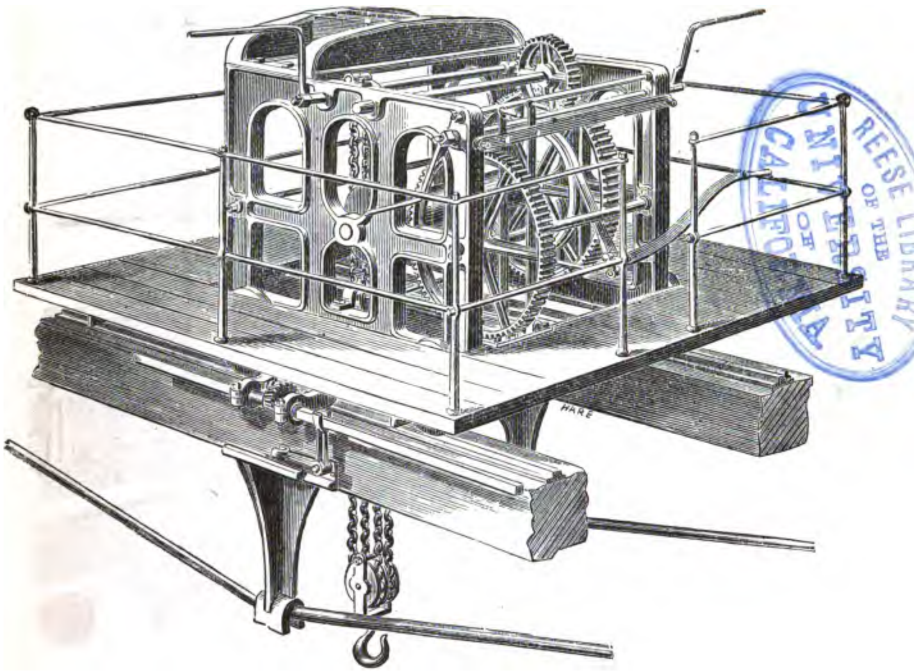


Fig. 160.

Travellers are made without the platform girder, and in this case the platform is attached to and moves with the crab (see Engraving, Fig. 160). This decreases the total weight of the traveller, but the crab is more expensive, so that the cost is practically the same as given at page 78; more height is required from the rail level, and the Engraving is given rather to illustrate the type than to recommend its adoption.

Where it is necessary to have the platform attached to the crab either for the purpose of saving the dead weight of a platform the whole length of the gantry, or for other local reasons, a platform suspended to the crab by a wrought-iron frame between the main beams is preferable; the platform attached to this frame first clears the deepest part of the beams or truss rods, and will work in a height of 4 ft. 6 in. from rail level and about 7 ft. 6 in. total height. The prices are the same as the Hand Travellers, see page 78.

TRAVELLER CRABS. The timber beams and truss rods for travellers required only for temporary use can often be constructed at the place where they are to be employed, almost as well as if the Traveller were supplied complete, and with great saving in freight and carriage; the cost of the crabs (which is the portion of the work requiring skill in design and workmanship) is therefore given. The crabs are complete with all motions up to the end of the bracket which carries the tumbler shaft, but the cost of no other ironwork, chains or blocks is included in these prices; these will however be found by reference to the index under their proper headings.

PRICES OF TRAVELLER CRABS ONLY, TO BE WORKED FROM ABOVE OR BELOW.

Power of crab	3 tons	4 tons	5 tons	10 tons	15 tons
Price, exclusive of chains or bottom block ..	£35 0	£40 0	£45 0	£55 0	£65 0
Approximate weight	1 ton	1¼ tons	1½ tons	2 tons	3 tons
„ measurement	60 c. ft.	65 c. ft.	70 c. ft.	80 c. ft.	130 c. ft.

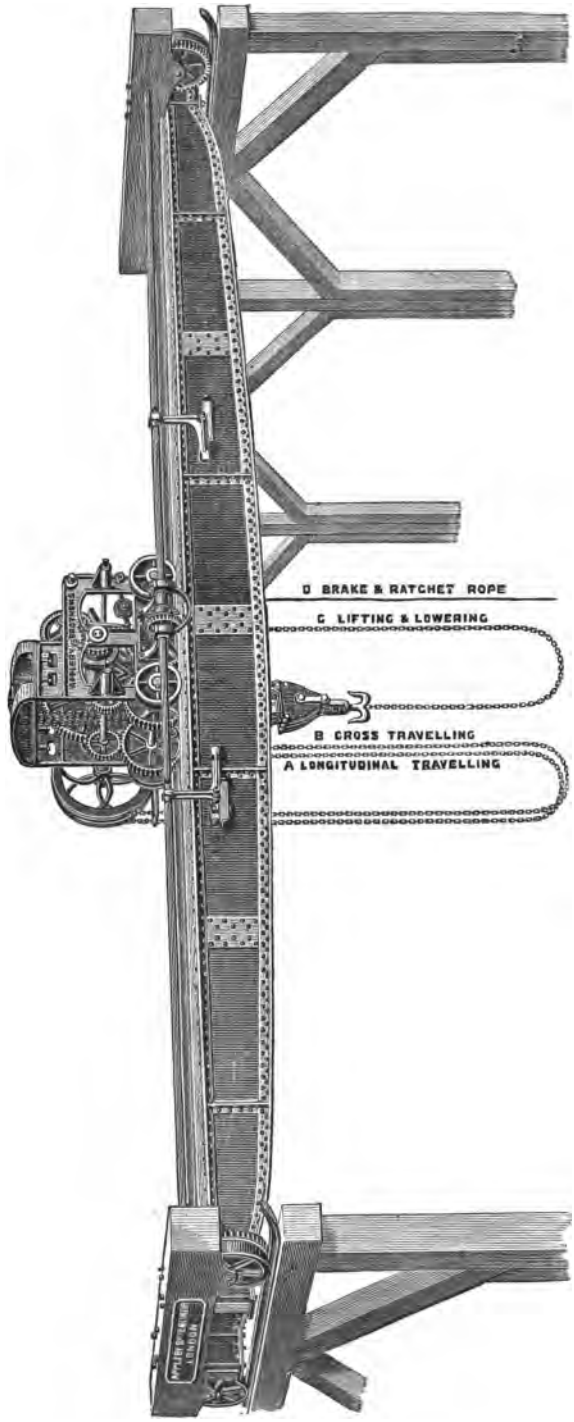

D BRAKE & RATCHET ROPE
C LIFTING & LOWERING
B CROSS TRAVELLING
A LONGITUDINAL TRAVELLING

Fig. 161.

HAND-POWER TRAVELLERS WORKED FROM BELOW, Fig. 161 (No. 8). The motions are generally similar to those described, page 73; but the handle and hand wheel for each motion shaft is replaced by a V. hauling wheel for an endless chain or rope; the brake and pawl being connected together and actuated by one cord, the pawl is lifted when the brake is applied, and *vice versa.* Travellers of this construction necessarily do not require platform girders, but they can be applied at any time and handles substituted for the hauling wheels. The Traveller, Fig. 162, is of the same type, but for loads from 1 to 3 tons, and will work in a very small space, only 3 ft. 6 in. from rail level being required. This form of Traveller is frequently used with boiler and girder rivetting machines, where the men employed at the machines can slowly move the work from hole to hole; also for placing logs on saw frames and similar work.

The prices include the lifting and hauling chains for a height of 15 ft. from floor line.

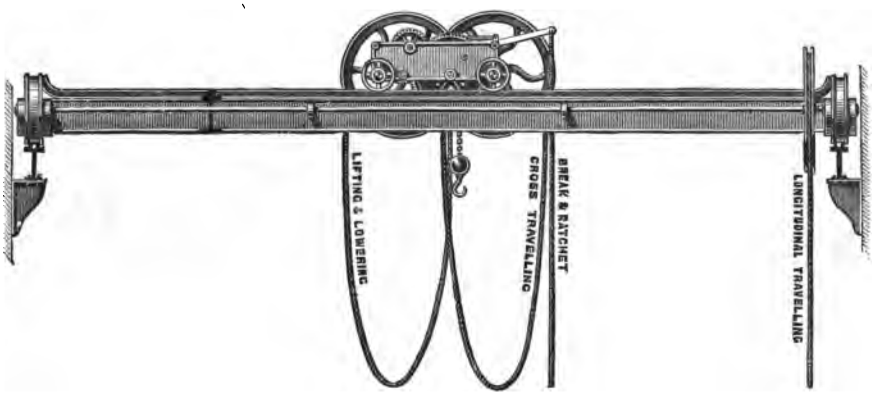


Fig. 162.

Power of crane	1 ton	2 tons	3 tons	4 tons	5 tons	10 tons	15 tons
Span of traveller ..	30 ft.	30 ft.	30 ft.	30 ft.	40 ft.	40 ft.	40 ft.
Height of lift	15 ft.	15 ft.	15 ft.	15 ft.	15 ft.	15 ft.	15 ft.
Price of traveller for timber-trussed beams ..	£80 0	£90 0	£100 0	£115 0	£135 0	£180 0	£270 0
Price per foot extra to 50 ft.	£2 0	£2 0	£3 0	£4 0	£5 0	£8 0	£10 0
Price of traveller with wrought-iron beams ..	£90 0	£100 0	£115 0	£130 0	£170 0	£220 0	£320 0
Price per foot extra to 50 ft., ironwork complete	£2 10	£3 0	£4 0	£5 0	£6 0	£10 0	£12 0
Approximate weight ..	2¼ tons	2½ tons	3 tons	4 tons	4½ tons	7 tons	10 tons
" measurement	100 c. ft.	120 c. ft.	140 c. ft.	165 c. ft.	190 c. ft.	250 c. ft	350 c. ft.

STEAM-POWER GOLIATH CRANES, Figs. 163 and 164. This form of travelling crane technically called a "Goliath," is specially adapted for use in station yards, quarries, timber and stone yards, as well as for building bridges or heavy girders; and as the crane runs on a pair of rails well laid at the ground level, no expensive structure is required to carry it. A crane of this type was designed and made by the Authors many years ago for use at the Runcorn Docks, then in course of construction from the designs of Mr. E. Leader Williams, and was subsequently altered to work under conditions where it was necessary for one end to run on the ground and the other end on a staging at a considerably higher level, involving the use of a long leg and a short one. These cranes can be made of any height or span: that illustrated in Fig. 163 lifts 40 tons and has a span of 40 ft., with a clear height of 22 feet. The beams and frames are of wrought iron, and the engines, boiler and gear are fixed against one of the side frames; the load is traversed across by a jenney and travelled longitudinally, lifted by steam power, the whole of the motions being controlled by one man.

The Goliath, Fig 164, is of 10-tons power and has a span of 40 ft.; the main beams are of wrought iron and the end frames of timber, stiffened by cast-iron brackets, but the

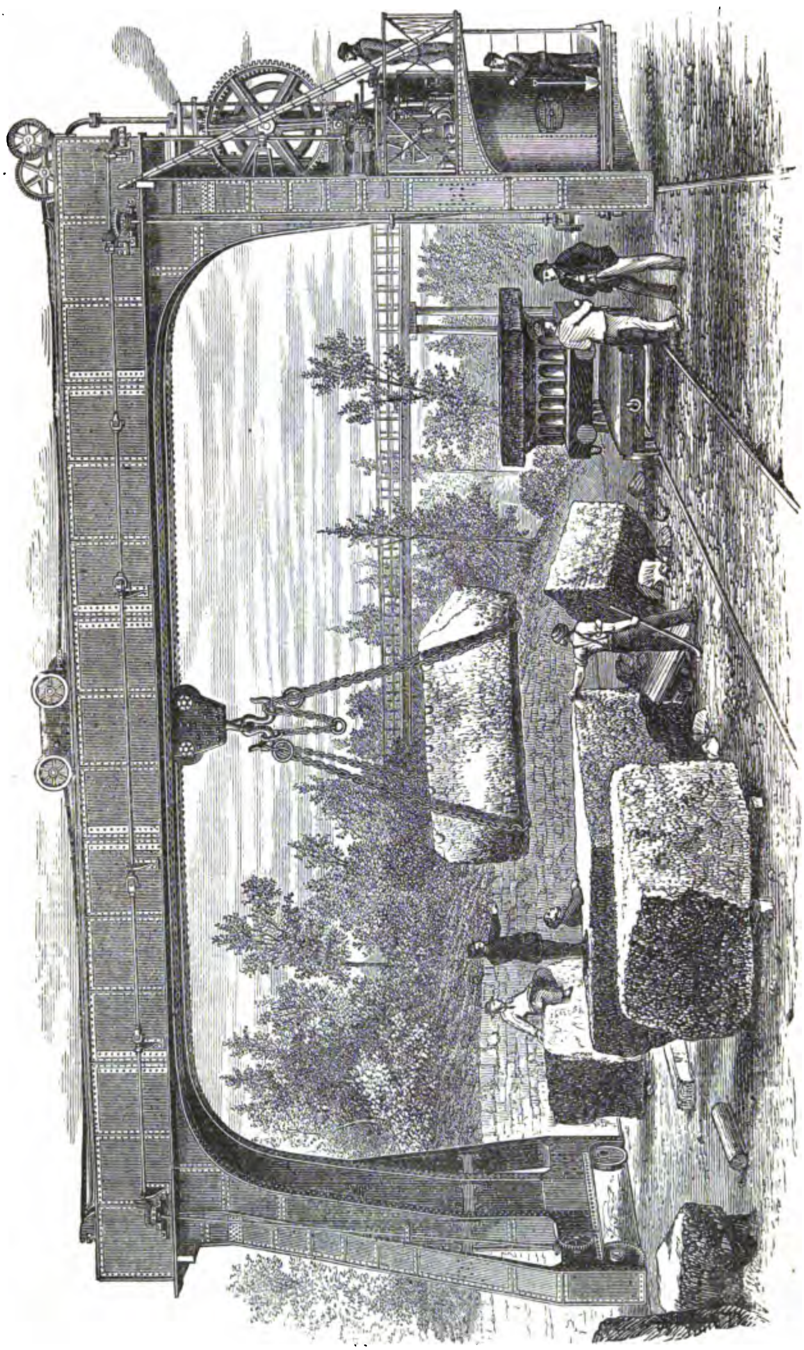


Fig. 163.

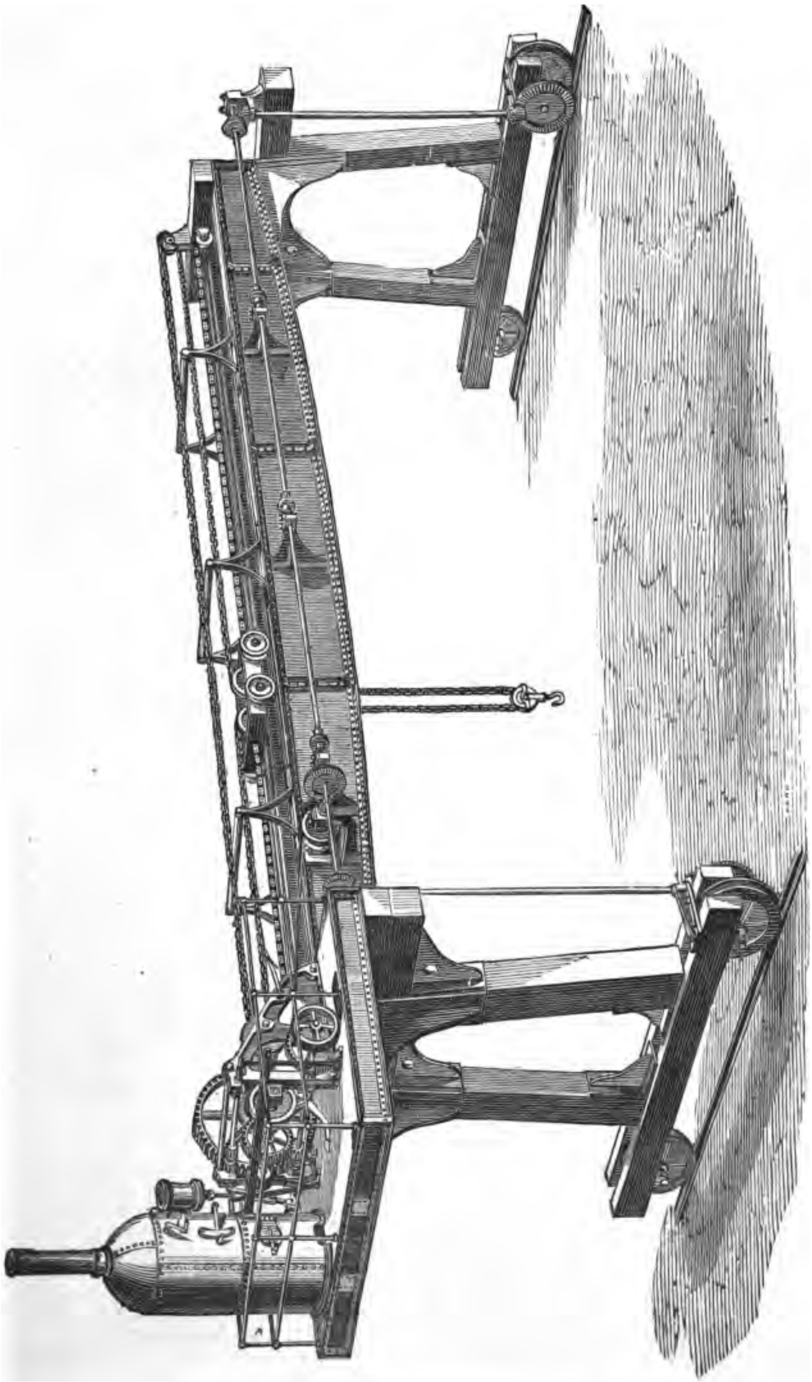


Fig. 164.

structure is frequently made principally in wrought iron; the engines, boiler, and gearing can be fixed on a level with the main beams, as shown in the engraving, or near to the ground line, as may be most convenient: in the latter case, the overhanging weight is carried by tie rods to the top of the frame, or by an extra set of wheels running on a third line of rails. This arrangement admits of the feed-water tank being used as a platform for the driver, and of the whole of the machinery being covered by an iron house.

The prices are for Goliaths of 40-ft. span and 20-ft. high complete, with chains to ground line. The cost of corrugated iron housing is the same as quoted for steam cranes at page 21.

Prices of Steam-power Goliaths, Figs. 161 and 162.

Power of Goliath	5 tons	10 tons	15 tons	20 tons
Span of Goliath	40 ft.	40 ft.	40 ft.	40 ft.
Height of Goliath	20 ft.	20 ft.	20 ft.	20 ft.
Number, diameter, and stroke of steam cylinders	2—5″×9″	2—6″×10″	2—7″×10″	2—7″×10″
Diameter and height of boiler ..	2′ 9″×7′ 0″	3′ 0″×7′ 0″	3′ 6″×7′ 0″	3′ 6″×7′ 0″
Price if constructed with wood-trussed beams and frames ..	£440 0 0	£560 0 0	£650 0 0	£750 0 0
Price per foot extra span to 50 ft...	£5 0 0	£10 0 0	£13 0 0	£15 0 0
Price with wrought-iron beams and end frames	£465 0 0	£625 0 0	£725 0 0	£850 0 0
Price per foot extra span to 50 ft...	£6 0 0	£12 0 0	£15 0 0	£20 0 0
Approximate weight	9 tons	15 tons	20 tons	25 tons
„ measurement ..	400 cubic ft.	600 cubic ft.	800 cubic ft.	900 cubic ft.

Power of Goliath	25 tons	30 tons	40 tons	50 tons
Span of Goliath	40 ft.	40 ft.	40 ft.	40 ft.
Height of Goliath	20 ft.	20 ft.	20 ft.	20 ft.
Number, diameter, and stroke of steam cylinders	2—7″×10″	2—8″×10″	2—8″×10″	2—8″×10″
Diameter and height of boiler ..	3′ 6″×7′ 0″	3′ 9″×7′ 6″	3′ 9″×7′ 6″	3′ 9″×7′ 6″
Price if constructed with wood-trussed beams and frames ..	£800 0 0			
Price per foot extra span to 50 ft...	£18 0 0			
Price with wrought-iron beams and end frames	£950 0 0	£1150 0 0	£1500 0 0	£2000 0 0
Price per foot extra span to 50 ft...	£20 0 0	£25 0 0	£30 0 0	£35 0 0
Approximate weight	28 tons	35 tons	42 tons	50 tons
„ measurement ..	1000 cubic ft.	1200 cubic ft.	1600 cubic ft.	1800 cubic ft.

At a slightly increased cost a steam capstan can be fitted for dragging stones in quarries, moving trucks, &c., or the construction may be modified to admit of one or more Goliaths being driven by a line of shafting in a similar manner to that employed for driving the Overhead Power Travellers, described at page 69. This arrangement has been adopted on works for constructing the heavy concrete or beton blocks now so generally used for breakwaters and harbour work, the power being taken from the engine used for working the concrete mixers and block-making machinery; and the cost is from 10 to 15 per cent. lower than for Goliaths having their own engine and boiler.

STEAM CRANE ON GOLIATH. Another modification is to have a steam crane fixed at one end of the framing, as shown in Fig. 160, or a steam portable crane to move from end to end on rails on the main beams. This subject has been discussed in many of the scientific journals both in this and other countries, with special reference to the various works executed by the Authors, and the following remarks are taken from a very interesting Paper on "The North Eastern Railway Company's Dock Extension Works at Middlesbrough," read before the Cleveland Institution of Engineers in April, 1874, by Mr. A. H. Whipham, who had charge of the whole of the works. "I wish to direct your attention to these cranes, constructed on the travelling-gantry system, seven of which will soon be at work, and which are the first of the kind erected anywhere, either in this country or abroad. The drawing,

No. 16 *, shows generally the features of the scheme. The reasons which led to their adoption were the fulfilment of certain requirements of which the following are the chief.

"The lengths of quay being limited, travelling steam cranes are a necessity, in order that they may be adjusted to suit the varying hatchways of different classes of vessels, and able to load ships, the sides of which are from 15 to 20 ft. above the water line at the top of high-water spring tides, an advantage which the ordinary type of steam crane travelling near the rail level does not possess. It frequently happens that no loading or discharging can be done at spring tide where these ground cranes are in use, on account of the jib fouling the ship's side. Also, to save labour, and for general convenience and safety, it is desirable that the man driving each crane should be able to see directly into the hatchway at all times, thus avoiding an extra man, or in some cases men, on deck to give instructions when to lift or lower.

"These gantry cranes, which are supplied by Messrs. Appleby of London and Leicester, fully answer the above-named conditions, and in every way justify the experiment of our being the first to introduce them.

"The steam cranes themselves are placed on the tops of the gantries on the side nearest to the quay. The span of each gantry is 23 ft. from centre to centre of the rails upon which it travels. The clear height from rail level to the underside of the girder spanning the two lines of railway underneath is 17 ft. 6 in., thus allowing the uninterrupted passage of locomotive engines and general rolling stock. The travelling wheels are 12 ft. apart centre and centre. The framing is composed of a pair of timber uprights, trussed and strengthened by cast-iron brackets, and by two wrought-iron plate girders, which are connected to the timber uprights by four wrought-iron brackets. A strong carriage of cast iron, with the necessary roller path and the gear for transmitting the travelling and capstan motions, is firmly secured between the wrought-iron girders at the side nearest the dock, while the girders are planked on the top, so as to form a coal bunker. Gas and water are supplied by means of pipes passing up the legs of the gantry, and are attached to the mains laid along the quays by flexible tubing.

"Each crane, with the whole of the superstructure, is designed for a quick working of about 3 tons, the maximum with double gearing being 5 tons.

"The radius from the centre of the crane post to the plumb line of the lifting chain is 24 ft., and the jib is fitted with steam derrick motion ranging from 14 ft. to 24 ft.

"The travelling motion is transmitted from the crane engine by gear and shafts to the travelling wheels and warping drums or capstans for drawing trucks, the latter being fitted into countershafts on the inside of the frames, and the whole arranged so that the capstans can be driven independently of the travelling wheels. This addition of the capstans, for hauling the trucks into position for each crane, is found to effect a large saving in time and labour. No horses or locomotive engines are ever employed excepting to bring or take away a train-load of trucks."

The "Journal of Industry" writes on this subject as follows:—

"THE introduction of steam cranes adapted and applied to loading and discharging ships' "cargoes, has probably effected a more substantial saving of time, labour and money than "any other class of machinery. So many interests are served by the rapidity with which "ponderous goods can be lifted from the ship's hold to the railway waggon or *vice versâ*, "that we may regard every improvement in this direction as a matter of vital importance to "the mercantile world. The crane plays a conspicuous part in the facilities and cost of "conveyance, because it grapples more or less successfully with the most difficult operations "of transit. We do not propose to enter minutely into the general application of improved "lifting power, but we desire to point out the importance of an efficient system of steam "cranes for loading and discharging cargoes.

"Messrs. Appleby Brothers, of Emerson Street, Southwark, London, have devoted a large "share of attention to this subject, and we are indebted to improvements introduced by them "for systems of steam cranes, which, when generally introduced at our large ports, cannot fail "to effect an immense saving of time and money.

"In a 'Report to the Communal Administration of the City of Antwerp on a system of "cranes to be employed for loading and discharging cargo at the port of Antwerp,' Mr. C. J. "Appleby exhibits a thorough knowledge of the requirements of a great commercial port, and "an accurate appreciation of the conditions to be fulfilled by a system of portable cranes "capable of dealing with all varieties of merchandise and different dimensions of vessels.

* Similar to Fig. 165.

" 'Vessels frequenting the port of Antwerp,' writes Mr. Appleby, 'vary so much in length and "beam that it would be impossible to regulate the distance between fixed cranes in such a " manner that there could be any probability of the total crane-power being at all fully " employed, and if it were not, the amount of capital sunk in the unemployed cranes, with " their foundations and accessories, would be unproductive. There is, however, the more " important consideration that, whilst endeavouring to berth ships under the cranes, a certain " length of highly valuable quay-room inevitably remains unoccupied, involving a further " amount of dead capital.'

" These remarks are really applicable to all ports where a considerable extent of dock or " quay offers facilities for vessels of all dimensions to lie alongside. Accepting, therefore, " portable cranes as the most convenient and economical for this class of work, it remains for " us to decide on the form of portable crane best adapted to meet the requirements of constant " work under all conditions of temperature, and at a satisfactory speed on occasions of great " pressure. After a careful consideration of the merits of the hydraulic and compressed-air " systems, Mr. Appleby rejects them in favour of the type of crane carrying its own steam " power. Of portable hydraulic cranes he speaks with the utmost fairness, and we believe " that he is fully justified in confessing that their failure hitherto has been 'due more to " defective design or construction than to any difficulty really inherent in the system.'

" But low temperatures interfere with the working of hydraulic power; and for this " reason alone they cannot be recommended in northern latitudes. Atmospheric cranes are " justly dismissed from consideration as too complicated and costly. It is possible that such " improvements may be effected in both hydraulic and atmospheric cranes that these objections " may be removed; but we have to deal with actual facts and results rather than vague " theories and conjectures. The question of supplying quays and docks with mechanical " appliances for the prompt loading and discharge of cargoes, is really a matter of national " importance. The loss incurred by every day's delay in the performance of this work is " distributed over a large number of people; but if accurately estimated, the total would be " surprisingly large.

" Manufacturers, shipowners, merchants, dock and railway companies, dealers and " customers, all suffer more or less by the delays consequent on an ineffective system of loading " and discharging cargoes. Mr. Appleby believes—and experience certainly justifies the " belief—that portable cranes in which steam power is employed directly, are preferable to " those in which it is converted into hydraulic force.

" 'The construction,' he says, 'first mentioned has been employed to a limited extent, and " has given more or less satisfactory results; but I avoid that construction, because, in addition " to the inconvenience already referred to when working in cold weather, the conversion of " steam power into hydraulic force involves a certain loss of power, which, together with that " incidental to a column of water passing at a very high pressure through the small area of the " inlet valve, is greater than is incurred in working spur-gear of good design and proportions; " and there is the further, and to my mind very important, disadvantage that the engine- " power is not available for some of the operations performed by cranes which

" '1. Lift and lower.

" '2. Turn completely round in either direction simultaneously with the lifting or " lowering.

" '3. Alter the radius by raising or lowering the jib head; and

" '4. Travel along rails by steam.'

" All these motions being easily worked by one man, who attends to the boiler.

" This type of crane will perform probably about 80 per cent. of the work of the docks; " but for dealing with the cargo of the largest class of seagoing vessels, which, when empty, " will rise to a considerable height above the level of the quay, a different construction is " necessary. 'The overhead steam crane, similar to that designed by Messrs. Appleby " Brothers, and erected by them at Middlesbrough Docks, meets the requirements of the " largest vessels, and enables the smaller cranes to pass to and fro beneath. The success " which attended the operations of this system has led to its adoption elsewhere. In South " America, as well as on the continent of Europe, modifications suitable to the class of work to " be performed have been introduced.

" 'At Callao, gantries are fixed at intervals, so as to work at least two hatchways of the " vessels frequenting each berth; the jetties are about 80 ft. wide, and there will be a range " of warehouses below each gantry parallel with the lines of railway on each side. The cranes " travel by steam ACROSS THE GANTRIES, and will load or discharge from the warehouses, trucks, " or vessels on either side of the jetty, as may be required.

" 'On the Continent of Europe cranes of a lighter type, mounted on a timber gantry, are

" found ample for the work to be performed. The machinery and ironwork are usually
" prepared in England, and are fixed to the timber framing, which is made on the spot;
" assuming the cost of timber work to be the same as in England, there is at least the saving
" in freight and duty.'

" As to speed of working the overhead steam cranes at Middlesbrough, we are informed that
" as much as 50 tons of pig iron have been shipped per hour by each crane; but of course much
" must depend on the facilities for bringing goods to the crane, and on the character of the
" goods themselves.

" The docks at Middlesbrough were constructed by the North Eastern Railway Company to
" meet the pressure of an increasing shipping traffic. The usual types of steam and hydraulic
" cranes then in general use failed to afford entire satisfaction to the dock authorities. They
" did not fulfil all the conditions demanded by a large traffic with vessels of all dimensions, the
" sides of which were sometimes 15 or even 20 ft. above the level of the quay. It was
" accordingly determined to submit the conditions to the engineering world, and to see what
" plan could be devised to secure an economical and effective system of cranes capable of
" grappling successfully with the heavy work of these busy docks. The design submitted by
" Messrs. Appleby Brothers promised to overcome every difficulty, and to satisfy every require-
" ment. It was accepted. The splendid system of cranes which we illustrate was completed,
" and their performances have surpassed the most sanguine anticipations of the dock authorities.
" They have really afforded a valuable lesson for dock authorities in all parts of the world, and,
" with modifications, they are applicable to the wants of all large ports.

" Our valuable contemporary, *Engineering*, has thus described these grand mechanical
" appliances :—

" 'THE travelling staging or gantry of each crane has a span of 23 ft. centre to centre of
" rails, one of the latter being laid close to the edge of the quay, and the other in the 6 ft.
" between rails. The clear height is 17 ft. 6 in., which allows the uninterrupted circulation of
" locomotives and all kinds of rolling stock on each of the two lines of rails which are spanned
" by the gantry. The travelling wheels are 12 ft. centre to centre. The framing is composed
" of a pair of timber uprights, braced and strengthened by cast-iron brackets and two wrought-
" iron plate girders, which are connected to the timber uprights by four wrought-iron plate
" brackets, strengthened with angle irons. A strong carriage, with the necessary roller path
" and brackets for the gear required to transmit the travelling motion, which will shortly be
" referred to, is firmly bolted at the extreme end of the girders nearest to the dock, while the
" girders are planked over so as to form a store for coal and water. The crane and the whole
" of the substructure is designed for a working load of 5 tons at the maximum radius of 21 ft.
" from centre of crane-post to the plumb-line of the lifting chain; while the crane itself is of
" precisely the same construction as those which have given satisfactory working results else-
" where, with apparatus for altering the radius by steam from a maximum of 24 ft. to a
" minimum of 14 ft.

" 'The travelling motion is transmitted from the crane-engines by suitable gear and shafts
" to the travelling wheels, and warping drums or capstans are fitted on a countershaft
" on the inner side of each frame, so that these warping drums can be driven independently
" of the travelling wheels, and they are used for moving the trucks into position below the
" crane, as they are required for loading and unloading. This simple addition is found
" to effect a very large saving in manual labour and time, which, it is estimated, amounts
" to at least £300 per year, because, without this appliance, horses and locomotives must
" be kept constantly employed, involving working expenses and wear and tear, in addition to
" the maintenance of the road, whilst with the capstans the trucks are brought into position by
" the men in stowing and slinging, with no further wear and tear of road than that due to the
" paying load. As it was decided to adopt this system of crane throughout the dock, the two
" lines of rails spanned by the gantry are laid with crossings at such intervals as will admit of
" either line being used for full or empty trucks, or in fact partially for both purposes if
" desired.

" 'Another great advantage which has been demonstrated by practice is, that the cranes can
" be so readily concentrated at any point where they may be required; and, indeed, as
" is shown in the engraving, three of these cranes are brought to load a long screw steamer
" having three hatchways. This is evidently a most important consideration with owners and
" shippers, especially under circumstances which so frequently arise where great despatch is
" essential. Or two cranes can be brought together for any exceptionally heavy lift. The
" cranes were tested with the maximum working load of 5 tons, and subsequently for speed,
" when each crane delivered 50 tons per hour from the trucks into the steamer's hatchway.'

" It will be manifest to our readers that such a system of steam cranes must be applicable

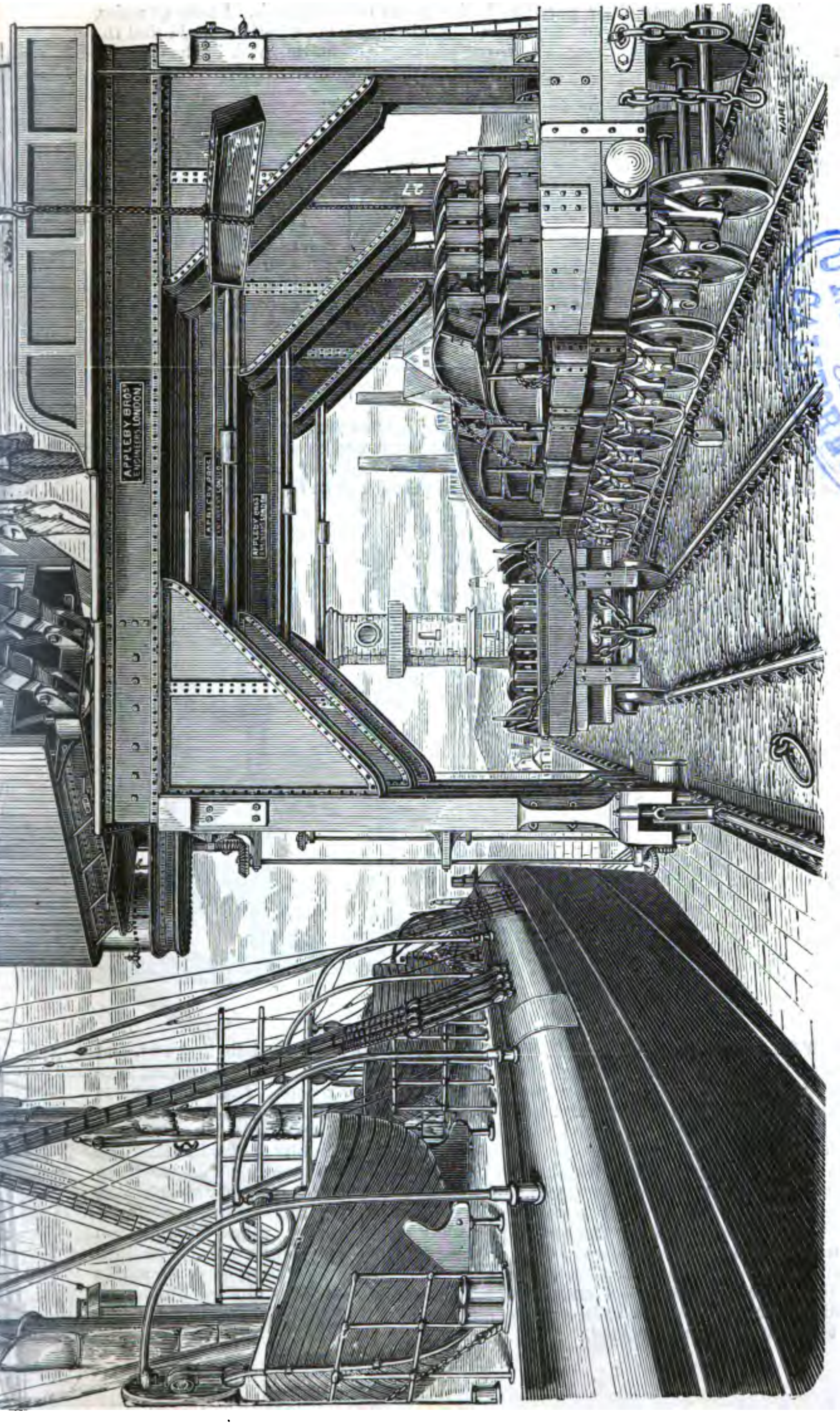


Fig. 165.

"with great advantage to many other purposes beside those of dock work. Stone quarries, "railway stations, and large factories and depôts having railway communication, would find the "system a valuable means of economising labour, and ensuring greater despatch in the delivery "of heavy goods."

PRICE LIST OF GOLIATH CRANES, Fig. 163.

Power of crane	3 tons	5 tons	7 tons	10 tons
Maximum radius of crane	18 ft.	20 ft.	20 ft.	20 ft.
Span of gantry	25 ft.	25 ft.	25 ft.	25 ft.
Clear height under beams	14 ft.	14 ft.	14 ft.	14 ft.
Price with timber framing.. ..	£600 0 0	£750 0 0	£900 0 0	£1100 0 0
Extra price per foot span up to 35 ft.	£10 0 0	£12 0 0	£15 0 0	£20 0 0
Price with wrought-iron framing ..	£700 0 0	£850 0 0	£1000 0 0	£1200 0 0
Extra price per foot span up to 35 ft.	£15 0 0	£18 0 0	£20 0 0	£25 0 0
Corrugated iron housing over crane	£20 0 0	£25 0 0	£28 0 0	£32 0 0
Approximate weight	18 tons	23 tons	30 tons	35 tons
,, measurement ..	700 cubic ft.	900 cubic ft.	1100 cubic ft.	1400 cubic ft.

The cranes have steam derrick motion to the crane jib, travelling motion to gantry, and single capstan on the gantry frame. If the crane is moved from end to end by power, the prices are about 10 per cent. extra. If with hand-travelling motion to gantry and without capstan, but the crane moving from end to end on the gantry, the prices will be the same as list.

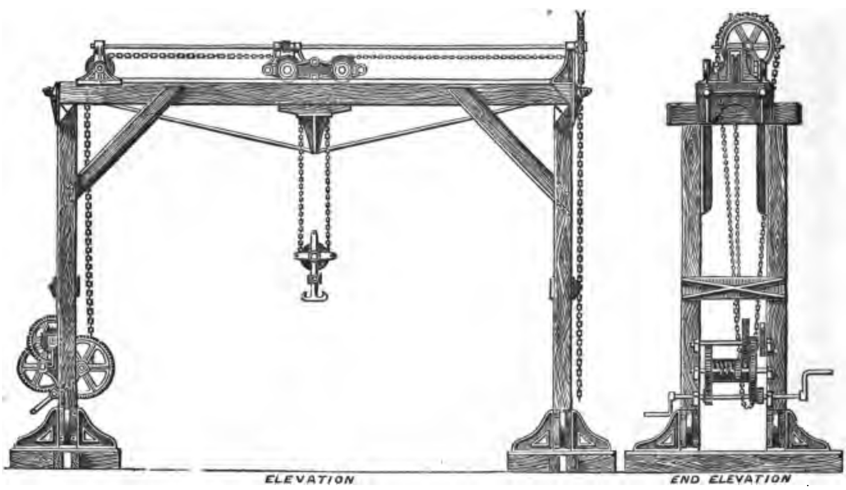


Fig. 166.

HAND-POWER GOLIATHS. Cranes of this construction are economical in first cost, and are usefully employed in railway station yards for moving heavy packages and for lifting locomotives, carriages, and waggons off their wheels for examination or repair. The same type of crane, but fitted with travelling wheels and gear, is largely used (especially on the Continent of Europe), for the purposes above named, as well as for li ting and traversing heavy girders, whether under construction or erection, and for similar purposes on public works, in stone and timber yards, &c. The height and width given in the subjoined list is usually ample, but these proportions can be varied to almost any extent, and the necessary data is given for ascertaining the approximate value of almost any span which may be required. The timber used is generally pitch pine or best Memel, and for the Goliaths made entirely of iron, rolled wrought-iron girders are used for the smaller sizes, and lattice or plate girders for the larger sizes. The fixed Goliaths have a cross-travelling motion, single and double-purchase lifting gear of ample strength, handles, brake, pawl-wheel and pawl, and chains to reach to ground line. The portable Goliaths are fitted with wheels, gear, handles, &c. (for travelling along a line of rails), in addition to the motions above named.

PRICES OF HAND-POWER GOLIATHS, Fig. 165.

Power	5 tons	10 tons	15 tons	20 tons	25 tons
Span	30 ft.	30 ft.	30 ft.	30 ft.	30 ft.
Clear height	20 ft.	20 ft.	20 ft.	20 ft.	20 ft.
Price with fixed timber frame	£170 0	£210 0	£300 0	£380 0	£460 0
„ „ portable timber frame ..	£200 0	£270 0	£400 0	£480 0	£570 0
„ „ fixed wrought-iron frame ..	£200 0	£260 0	£370 0	£460 0	£550 0
„ „ portable wrought-iron frame	£250 0	£390 0	£500 0	£580 0	£690 0

The cost of Goliaths of longer span may be approximately ascertained by adding the same extra price per foot as is given in the list of prices for overhead travellers of equal power. The cost of ironwork only, ready to fix to timber, is about one-third less than for the Goliath with timber frame complete.

TITAN, Fig. 166. Probably in no branch of mechanical science has greater progress been made than in the design of appliances specially adapted for dealing quickly and economically with those ponderous blocks of stone or concrete now and for some years past used in the construction of breakwaters, harbours, and docks; and, although it is not within the scope of this article to record in detail the improvements which have so rapidly followed each other in this class of machinery, it may be interesting to refer to some examples, and to the conditions under which they have been successfully employed.

The timber staging (often constructed under great difficulties, due to the nature of the bottom, bad weather, &c.), which formerly was almost invariably used, was carried considerably in advance of the works, but in many instances this became a total wreck, and the work has had to be gone over again, causing great delay and extra cost; even those remarkably fine examples of staging used in the construction of the Dover Harbour under Sir John Hawkshaw, and the Tynemouth Harbour works, designed and carried out by Mr. Messent, were swept away and had to be reconstructed.

The object of the crane appropriately called a "Titan," is to lift blocks of from 20 to 30 tons' weight from the trucks and place them in position *in advance* of the finished work, and thus to dispense entirely with the use of staging; it was first used for this purpose in the Manora Breakwater. The Titan, illustrated in Fig. 167, fulfils all the conditions indicated when tenders were invited for the work.

Those conditions were, that the blocks, each weighing 27 tons, should be lifted, traversed out, and placed in position 25 feet in advance of the point of support afforded by the finished work. The main framing is made throughout of wrought iron, and travels on a pair of rails, 22-ft. gauge, which were carried on blocking pieces up to the front face of the work, as shown in the engraving; the height from rail level to the upper side of the projecting girders is 20 ft. The lower members are of box-girder section, and are fitted on each side with two pairs of wheels placed close together, fore and aft, travelling on the rails above named, and the front group can be relieved of the strain due to the weight of the block, by powerful short-stroke hydraulic jacks placed under the front end of each girder.

The engines are 2 7-in. cylinders with link-reversing motion; the boiler is of the vertical type, and the several motions for lifting and traversing the load and for moving the Titan are transmitted by suitable shafts and gear with the necessary clutches and levers. The engine and boiler are mounted on a platform laid on the transverse girders, tying the two frames together; a pair of wrought-iron tanks capable of holding 30 to 40 tons of water ballast are fixed over the trailing wheels and form part of the framing. The cost of the Titan is £2500, the weight 85 tons, and the duty, 6 blocks laid per day, allowing for the time required for the divers to place the blocks under water.

The cost of the 10 trucks, which were required for bringing the blocks from the drying ground, was £180 each, and the weight 7 tons each

A convenient form of Goliath for lifting the blocks, after they are dried and are required for use, is one with a direct-acting hydraulic cylinder and ram of the stroke required to lift the block on the trucks, the ram and cylinder being mounted on a travelling jenny with an engine and boiler of sufficient power to give the travelling motions and to work the hydraulic pumps. The cost of this for 50-ft. span is £1150, and the weight 30 tons.

Since the work above referred to was designed it has been found necessary to use blocks weighing 40 tons, and the Titan for laying them has a swinging jib of about 50-ft. radius, carried on a frame somewhat similar to that already described; the jib is provided with swinging gear, and describes an arc of about 190°, and will lay stones across a face nearly 100 ft. wide.

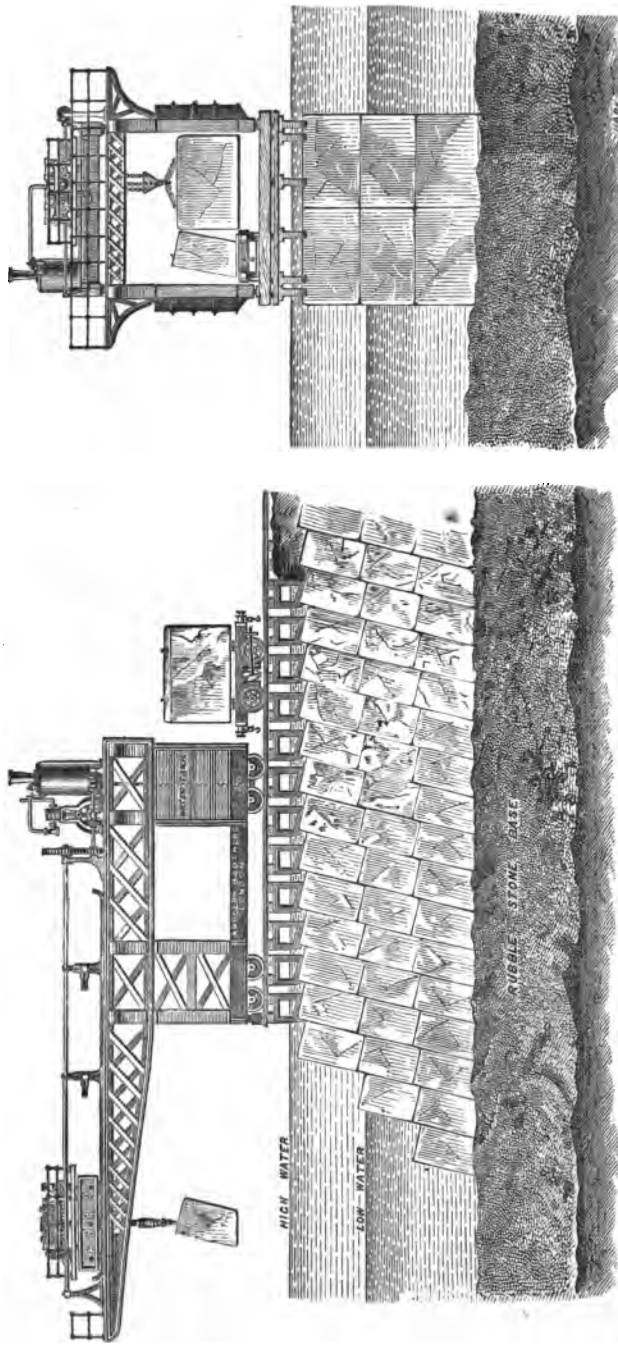


Fig. 167.

Admirably as these arrangements are adapted for conditions under which they have been used, other conditions require machinery of an entirely different character. At the large harbour works at Alexandria, now nearly completed, the concrete blocks were made at Mex, across the bay, and were conveyed from the block-making ground in barges which were towed by a steam tug to the various points where they were required; the blocks weighed about 30 tons each, and were lifted out of the barges and deposited, often in deep water, by floating steam derricks, an improved type of which is illustrated and described at pages 17 and 18.

An inexpensive but efficient arrangement was adopted by Sir Charles Hartley, in the works of the Danube Improvements, for depositing the 20-ton blocks, which were largely used. This consisted of a pair of masts stepped into the forward end of a large barge and tied back aft. A pair of strong blocks were hung from a link at the head of the masts, and the chain carried back to a powerful winch, which in this case was driven by cross and open straps from a small steam engine. The cost of the blocks, bridle and winch, with pulleys, was only £120.

It will be unnecessary further to trace the varied character of the machinery employed on the large works carried out in different parts of the world within the last few years. In some cases it has been necessary that the work should be executed in the shortest time possible, with a relatively large outlay in plant, whilst in others it has been essential that this item of cost should be kept low, or the work distributed over a long period; hence the mechanical appliances have in nearly every case been specially designed for each undertaking.

The machinery for making concrete blocks will be found at Section 5.

SHEAR LEGS OR MASTING SHEARS, Fig. 168, are chiefly used in dockyards and marine-engine works, and the great height they will lift above ground line renders them invaluable for placing on board the engines, boilers, machinery, guns, masts, &c., required in the equipment of vessels. The reach over from the quay line is regulated by the back leg, and the vessel is warped ahead or astern until the position is obtained for lowering the load in the place where it must be deposited. This kind of crane can be constructed for any given height or load at less cost than a swing crane of equal power, but having motion in only one direction—from the quay outwards—it is only available for loading or unloading vessels afloat or vehicles on wheels.

The legs are usually built up of wrought iron, either square or cylindrical, hollow in section, and made in lengths which are rivetted up with butt strips inside and flush rivets; the legs taper from the centre to the ends, which gives a light and neat appearance. The two front legs are jointed at their lower ends into a pair of heavy cast-iron shoes, which are secured to the masonry of the quay wall; the bottom end of the back leg is jointed to a massive slide block working in a pair of cast-iron guides, which are also firmly fixed to the masonry at some distance back from the front wall of the quay, and the three are united at their upper ends by a massive cap and joint pin to which two pairs of blocks are attached, one set for light loads and the other for the maximum load. The single chain from each set of blocks is led back to the gear placed in the rear of the back leg, and a small steam engine and boiler (about 12-horse power) give the motive power required for lifting and for traversing the back leg. The machinery referred to and illustrated, Fig. 168, is of 60-tons power; the length of the front legs is 90 ft., and the back leg 120 ft.; the reach over from quay line is about 37 ft.; and the cost, ready for erection, is about £3300. The weight is about 100 tons.

Shear legs for lighter loads, and of a cheaper construction, are made mainly of timber, and are adapted to work by hand or steam. For unloading locomotives the lifting power is 30 tons, and the maximum reach over is 25 ft. when 45 ft. high. The cost of the Shears complete is £1000, and the weight about 35 tons. The cost of a complete set of ironwork is £600. The cost of a similar set of Shears, but of 15-tons power, 15-ft. reach, and 25 ft. high, is £500.

The back leg in this arrangement terminates in a strong screw which works through a nut and is geared to the hand or steam winch; this nut is carried in trunnions, and so maintains its central position as the back leg is altered in length. The back leg is coupled at the junction with the screw by a pair of radius bars or frames.

COALING DERRICKS. The introduction of steam into our ships of war, mail steamers, merchantmen, and colliers, necessitates the provision of coaling stations or depôts, at various ports at home and abroad, and the construction of "Coaling Derricks" as they are called, has received considerable attention. The usual plan is to provide a hull of great tonnage and capacity, often the dismantled hull of a man of war, or of a large vessel past active service, and to fit this up with a complete system of cranes (either steam or hydraulic) to cheaply and quickly discharge coals from sailing ships or screw colliers into its hull, and as quickly to put them on board the vessels requiring to be coaled. The cranes are usually of about one-ton power, fixed on each side of the hull, so that steamers or ships can be put alongside on both sides of the hull; these cranes are fitted with swing jibs worked by power, and weighing apparatus when desired. All the cranes are worked from one set of engines and

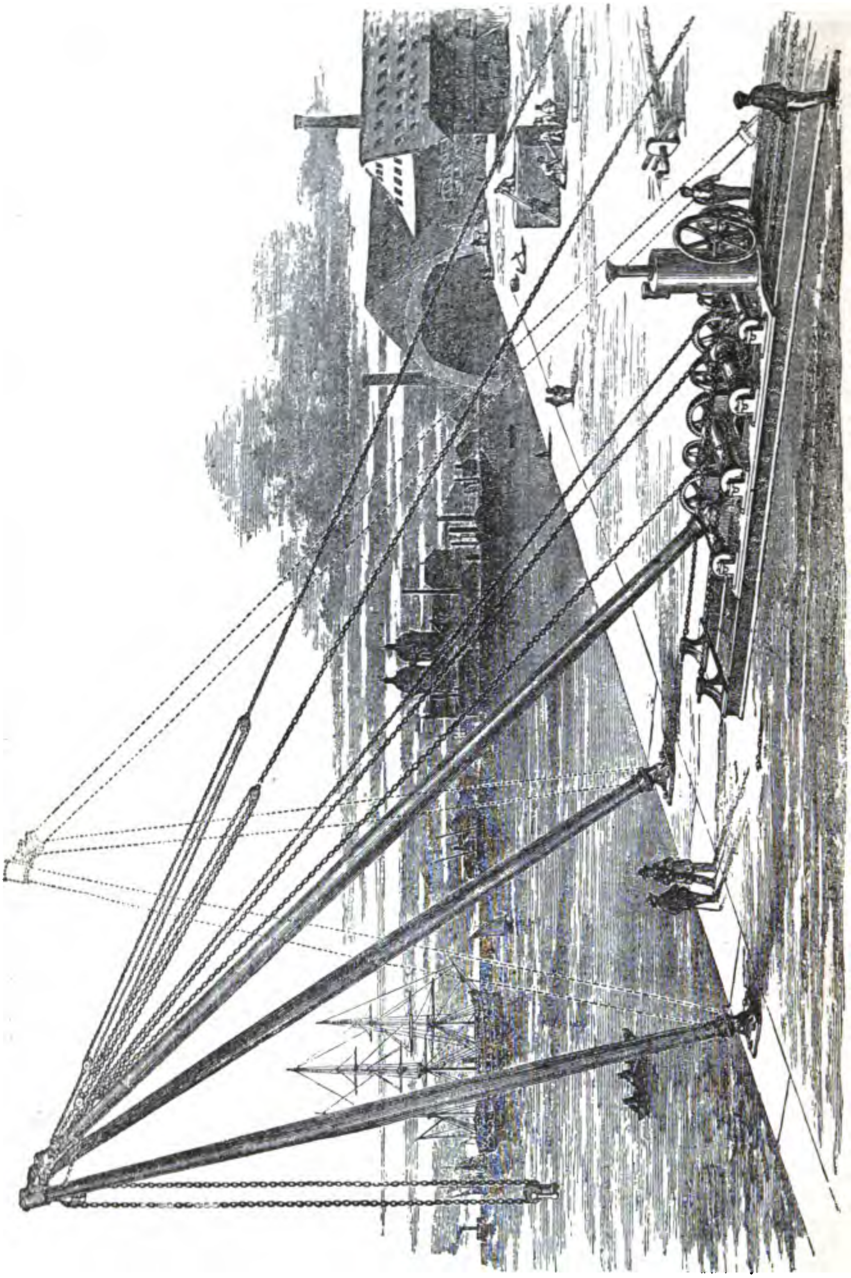


Fig. 168.

boilers placed in the hull, and such is the facility afforded by a properly-equipped Coaling Derrick that a 1000-ton steamer can be discharged in a few hours.

Coaling Derricks for use at home are generally fitted with screening apparatus, so that the coals can be taken from the hold of a steamer, weighed, screened, and discharged into barges lying alongside, at one operation.

COAL TIPS. The arrangement above described is that best adapted for dealing with sea or water-borne coals, but for coals conveyed by rail for shipment at a port or dock, at all heights of tides, and into ships of all sizes, without breaking the coals by any unnecessary height of fall, considerable difficulty is incurred, and other arrangements must be adopted.

If the coals are delivered at the quay at a considerable elevation, as is sometimes the case, the trucks are run on a tipping cradle at that elevation; this cradle is nearly counterpoised by balance weights attached by chains to the cradle, and working over pulleys, the controlling power being a powerful brake on the same shaft as the chain pulleys. When the brake is released the truck will descend until the back part of the cradle comes in contact with stops which can be fixed at any required elevation, and the front end of the cradle then will continue to descend until the required angle is obtained for discharging the contents of the trucks into the ship; the balance weights under the control of the brake restore the truck first to its horizontal position, and finally, to the elevation of the rail.

But it frequently happens that the rail level on which the trucks are run is much *below* the deck of the ship; it then becomes necessary to raise the loaded truck before it can be tipped into the hold of the vessel: this is usually accomplished by a tipping cradle lifted by a hydraulic ram of sufficient power and stroke for the maximum load and height of lift required; the truck having been run on to the cradle is then lifted to the desired height; the front end of the cradle comes into contact with adjustable stops, and the ram continuing its course, raises the cradle to the desired angle for discharging the contents of the truck; or in some cases a separate ram and cylinder are used for the tipping operation, and a compensating cylinder is attached to return a portion of the water back into the pressure mains by the lowering of the empty truck down to rail level. A truck with a 10-ton load can be put on the cradle, lifted, tipped, and returned to the rails in two minutes.

A very useful set of machinery was constructed by the Authors for the Dutch Rhenish Railway Company, for use at Amsterdam, where the water level and height of barges is constant. It consisted of a cradle jointed on the fender pile, and in a pit below the cradle was placed a 9-in. hydraulic ram and cylinder with a stroke of 6 ft.; this cylinder was hung in a pair of trunnions near its top end, and the ram had a spherical end working into a suitable socket on the under side of the tipping cradle, forming a ball and socket joint; the rails were curved on the front end of the cradle for the wheels to run up against, and when the truck was put on and the pump started, the ram lifted the cradle to the necessary angle to discharge the coals into the barges, the waggons having drop ends, and carrying 12-ton loads. The power was supplied by a double-cylinder engine and vertical boiler of the type shown in Fig. 24, and was fitted with a double-action hydraulic pump, 3-in. diameter by 12-in. stroke, working direct into the cylinder, a relief valve being provided so that the ram could not be forced beyond a given point out of the cylinder. This engine was also fitted with capstan ends for shunting the trucks backwards and forwards on to the tip, and swinging them on the turntables; this was done by a tow rope and leading pulleys fixed at various points, and the rope led on to the capstan. Twelve trucks are easily shunted and discharged per hour, and the cost of the whole of the machinery was £500.

Another and still more simple form of tip has frequently been constructed by the Authors. Several are at work at the Ebbw Vale Company's wharf at Watchet, and are used for discharging hematite iron ore into the ships in the harbour. In these tips the cradle is altogether dispensed with; the trucks are run up against a pair of curved rails, and a cylinder and ram on trunnions is used, similar to that above described, but with the top of the ram fitted with a wrought-iron fork to lay hold of one of the axles; and as the ram ascends the truck is tipped on the other axle, the wheels of which form the fulcrum, the curved rails keeping the wheels from moving. Four of these tips (two on each side of a stone pier) are worked from one small horizontal engine with cylinder 9-in. diameter by 18-in. stroke, fitted with direct-acting hydraulic pump of the same stroke as the engine; and when the engine is not pumping into either cylinder it pumps through a relief valve back into the supply cistern. This engine also drives a vertical capstan by underground shafting and strap, fixed in a convenient position relatively with the four tips; a treadle being depressed by the attendant's foot, the strap is shifted on to the fast or driving pulley, and on removing his foot a counter weight takes the strap back on to the loose pulley. A vertical boiler is used for generating steam for the engine, and the whole cost of the machinery for the four tips, including four strong wrought-iron shoots, with counter-balance weights, crabs for lifting, and steam and hydraulic connections, was £900. This arrangement has given very good working results.

The same form of Tip could be worked from a small accumulator, and would give a rather

increased speed of working, and possibly a little economy in engine power, but the first cost of the machinery would necessarily be higher. This could in some cases be compensated by utilising the power of an engine employed for other work, the water power being readily transmitted to a considerable distance without appreciable loss.

With Welsh or any highly bituminous coal which is very liable to breakage, tipping, unless carefully conducted, causes so great a loss in the commercial value of the coals that it has positively been found more remunerative to ship them by hand labour in barrows than submit them to ordinary tipping. To avert this it is now the practice to put the first layer of coals into the hold of a ship by drop-bottom boxes and a crane worked from the same power as the tip, until a cone or pyramid is formed reaching the deck, after which the shoots are carefully adjusted to tip on to this cone. These shoots are also fitted with a screening arrangement and a sort of baffle at the point, so that the coals will not run out until they are trimmed down the hold.

STEAM LIFT OR HOIST, Fig. 169. Vertical lifts of this type are of great service for transporting goods from floor to floor of warehouses. The construction usually adopted is to fix four vertical square guide timbers, which pass through the various floors and are firmly fixed to them; if the floors are of considerable height, the guides are diagonally braced. A wrought-iron frame or cage (and in some cases only a platform) is fitted to and guided by these timber uprights; a framework is fixed on the top for the purpose of carrying the chain sheaves and balance-weight sheaves, and over these pulleys chains are passed from the cage to the chain barrel of the steam hoist, which is illustrated on a larger scale (Fig. 106) and fully described at page 9; from the opposite side of the chain barrel another chain is led over the top pulley to the balance weight, so that as the chain attached to the hoist is wound on the barrel, the chain to the balance weight is run off.

The hoist is fitted with reversing motion, which is worked from each floor with a single lever only.

Where a great quantity of work is required, there are two cages or platforms which balance each other and dispense with the necessity for balance weights; in that case six upright timbers are used for the framing.

This form of lift is sometimes fitted with safety apparatus to sustain the cage if the chain should break, and with self-acting gear for stopping the cage automatically at the top and bottom of its travel; this is always done when the lift is used for passengers, and if desired it can be worked from the inside of the cage, the attendant travelling up and down each time with the lift. This is considered an extra element of safety, as a special attendant will naturally pay proper attention to the working of the hoist.

The steam for supplying the hoisting engine can be taken from any boiler on the premises, and several are frequently worked from one boiler. If a boiler has to be provided specially for the lift, it is usual to place it in a yard, or in some cases on cantilevers fixed to the outside of the wall, so as not to affect the rate of insurance against fire.

Lifts are also often fixed *outside* a building in front of the loophole doors, the engine and boiler being at the bottom of the framing. The cage is brought to a level corresponding with that of the carts or vans, and the contents are discharged directly into the cage and are raised to the level of any floor without further handling.

Hoists of these types have been designed and erected by the Authors for the East and West India Docks, &c., but the conditions vary so much that it is impossible to give general prices. In some cases it is required that the work should be made complete, including brick and woodwork, boiler power, &c., whilst in others this is done by the purchaser; and, again, almost every lift varies in the size of cage, height of lift, and weight to be lifted.

HYDRAULIC HOISTS. The form of cage shown in Fig. 169 can be worked by hydraulic machinery identical to that illustrated at Fig. 124, p. 36, for working an outside crane jib; but the turning cylinders are of course not required. If the loads vary much in weight, and the height of lift is also considerable, a three-cylinder arrangement would be advisable, for the sake of economy, as explained in the remarks on Wharf Cranes, Fig. 123, at page 34.

HYDRAULIC DIRECT-ACTION HOIST, Fig. 170. This system is preferred to all others for passenger lifts, on account of the smooth and noiseless action and the almost absolute impossibility that any derangement should occur sufficient to cause an accident. It consists of a hydraulic cylinder equal in length to the height of the desired lift (sometimes 70 ft. and upwards), placed vertically in a well or bore hole, and a ram of area proportionate to the work to be done and the pressure of water available. The cylinder is fitted with a gland or leather collar, and on the head of the ram rests the cage or ascending room, which is guided by suitable guide timbers. The motion is regulated by an equilibrium valve, admitting the water into the cylinder or letting it run to waste. The valve can be controlled from a rod which passes down one corner of the lift, and only requires a gentle pull to stop at any desired floor or to start again.

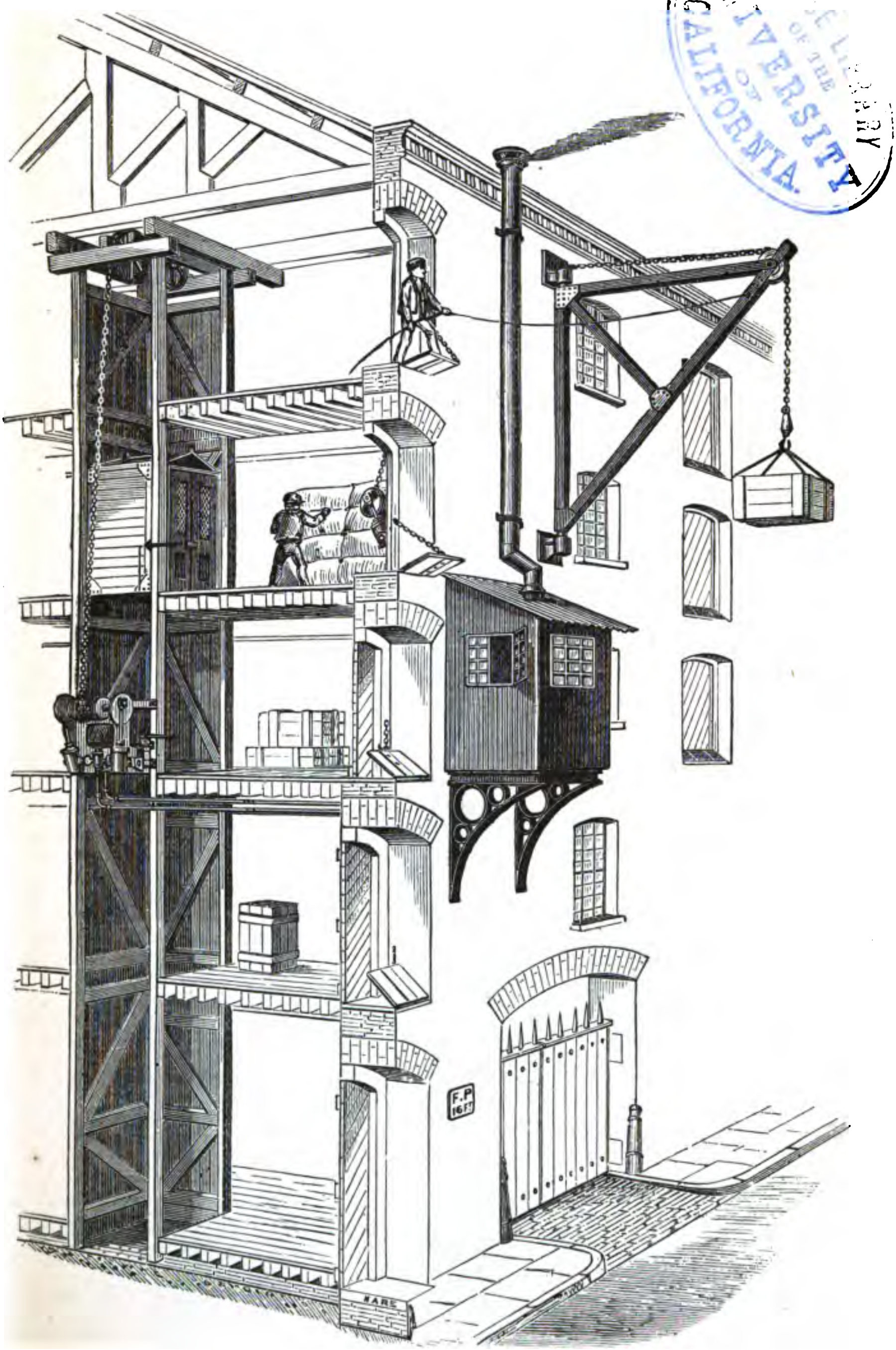


Fig. 169

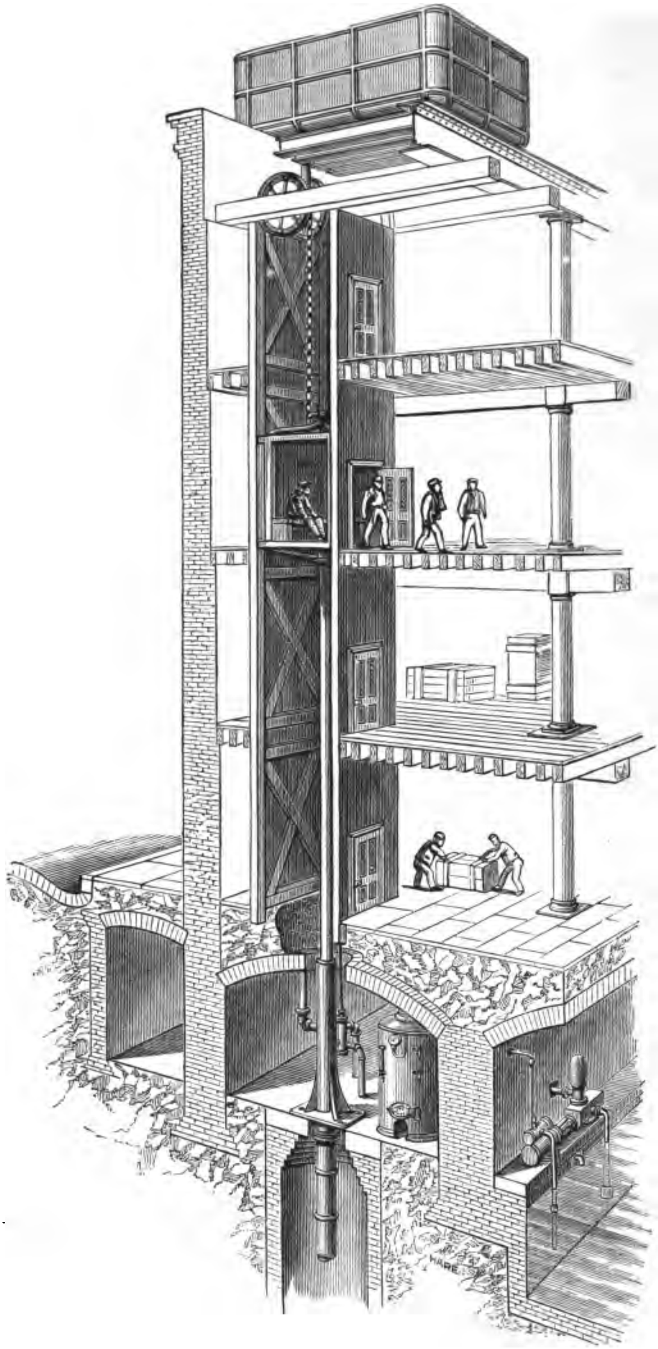


Fig. 170.

These lifts are always fitted with compensating counterbalances, exactly equal to the weight of the cage and the ram at all points of its stroke, ensuring the utmost economy of water in working. The water pressure is obtained in various ways, from an accumulator of the kind described at p. 35, and into which the water is forced by steam power and pressure pumps, one accumulator being used for working a number of such lifts together with cranes, capstan engines, dock-gate engines, &c., or it may be taken directly from the water company's mains, if there is a high-pressure service and the water may be used for such a purpose: but in London and in many large towns the companies appear studiously to restrict the use of water for lifts, small water engines, &c.; whilst in Leeds, Bradford, and other towns in that district, where this privilege can be obtained, many water engines, lifts, &c., are used with manifest advantage to the consumer and to the water company.

To obviate the inconvenience experienced from a defective water supply, recourse is had to a tank placed at the highest elevation available, supplied by a small pump and steam engine; and after the water has been used, it flows to a low-level tank and is again lifted up into the high-level tank, the same water being used over and over again. The supply in the first instance is obtained from a well or the company's main, or from some source near the surface.

The Lift, Fig. 170, is erected on the premises of Messrs Gooch and Cousens, of London Wall. The ascending-room is 6 ft. by 6 ft. and 7 ft. high; the room has seats on three sides, and will take twelve persons at one time, and is fitted up like a first-class railway-carriage; the roof is of glass with a lamp in the centre. The sales are held on the top floors of these spacious warehouses, which are about 40 feet above the ground floor, the light being so much better there than on the lower floors, and the lift is used to carry the wool-buyers to and from the salerooms, or to any floor of the warehouse. The whole of these warehouses have been fitted with cranes and machinery by the Authors' firm.

The cost of the machinery, including large top and bottom tanks, mains, steam pump and boiler for same, was £860; and the cost, including the necessary timber work, sinking cylinder, and erecting the whole, was £250.

This kind of lift is used in many of the best hotels as well as in public buildings, hospitals, and offices, and even in the large private offices and blocks of buildings which are now erected in commercial towns. A man in charge of the lift makes the full ascent and descent about once every two or three minutes, including stopping to let out or take in passengers at any of the intermediate floors.

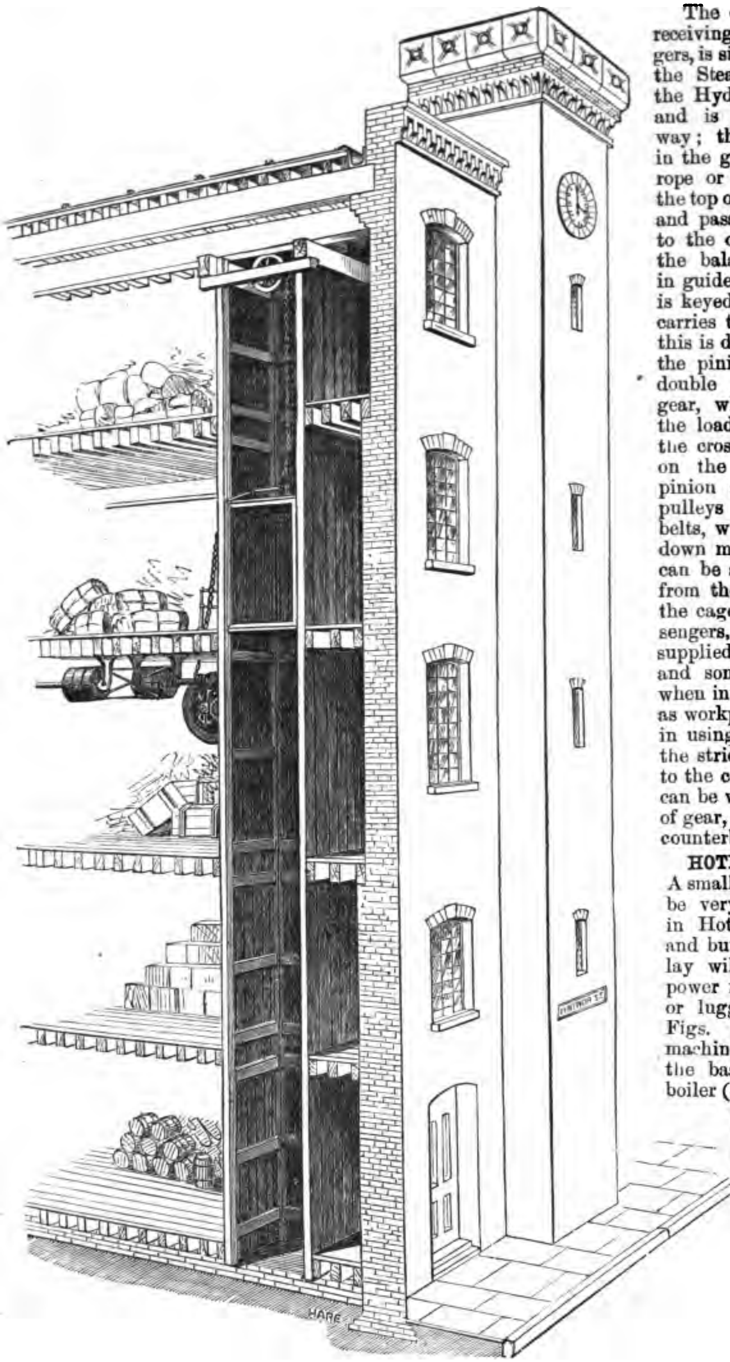
The Authors have erected lifts of this kind for use in several royal palaces, the ascending-rooms being 10 to 12 feet square, and luxuriously fitted and decorated.

A similar form of lift is also much used for banks, to take up the books and bullion from the strong rooms in the basement to the first and second floors, and many are now working with all kinds of pressures, each giving excellent results; of course the greater the pressure available, the *lower* will be the cost of the lift for a given load and height; but the conditions are so very varied that a tabular list of prices cannot be compiled; but a bank lift equal to 12 to 15 cwt., with a 12-ft. lift, working with 60-feet head taken from a tank fixed on the top of the building, and supplied by the water-company's mains, costs about £130. including erection in London.

Where no head of water is obtainable either directly from mains or from a tank, the ram is lifted by water being pumped into the cylinder by a pair of pumps fixed on a cistern, and having about the same capacity as the cylinder; the pumps are worked by hand, and being double, a steady, *smooth*, safe, and noiseless motion is obtained, these conditions being most essential in a bank or office. A variety of powers can be given by altering the stroke of the pumps, or working one or both at once, and the lowering is perfectly controlled by a small relief-valve, which allows the water to flow back into the pump cistern; the top of the lift often forms the iron door to the opening and if the water is confined by the valve in the cylinder, it *securely* locks the opening to the strong room, without any other locking apparatus. This construction is adapted for lifts with a small diameter of ram and cylinder.

LIFT DRIVEN BY SHAFTING, Fig. 171, for use in factories, works, and warehouses, where power can be taken from existing shafting.

Power of lift	10 cwt.	15 cwt.	20 cwt.
Height of lift..	30 ft.	30 ft.	40 ft.
Size of cage	3 × 3 ft.	3 × 3 ft.	4 × 4 ft.
Price, ready for erection, exclusive of timber work, &c.	£65	£80	£100
„ with safety apparatus	£15	£20	£25
Approximate weight	40	50	65
„ measurement	60	90	110



The cage, or platform for receiving the goods or passengers, is similar to that used for the Steam Lift, Fig. 169, or the Hydraulic Lift, Fig. 170, and is guided in a similar way; the difference consists in the gearing; in this case a rope or chain is attached to the top of the cage or platform, and passes over a pulley, and to the other end is attached the balance weight working in guides; a large spur wheel is keyed on the spindle which carries the chain pulley, and this is driven by a spur pinion, the pinion being fitted with double safety ratchet brake gear, which instantly holds the load stationary whenever the cross or open belt is put on the loose pulley. The pinion shaft is fitted with pulleys for cross and open belts, which give the up and down motion, and these belts can be arranged to be worked from the inside or outside of the cage. When used for passengers, the hoist should be supplied with safety apparatus, and some are so fitted even when intended for goods only, as workpeople so often persist in using the lift, even when the strictest orders are issued to the contrary. Double cages can be worked by the same set of gear, and one cage will then counterbalance the other.

HOTEL OR OFFICE LIFTS. A small steam engine can often be very profitably employed in Hotels and large offices, and but little additional outlay will provide the extra power for working passenger or luggage lifts of the type Figs. 170 and 171. The machinery may be fixed in the basement, and if a gas boiler (see p.) or a caloric engine (see p.) is used, no extra charge should be incurred for insurance.

Fig. 171.

HAND-POWER LIFTS, Figs. 172 and 173. In warehouses, hotels, &c., where neither steam nor hydraulic power is available, and where the work is not of sufficient importance to pay for putting down steam power, the Lifts shown in these Engravings will be found compact, simple, and easy of management, and every expedient is adopted to reduce the power required to work them.

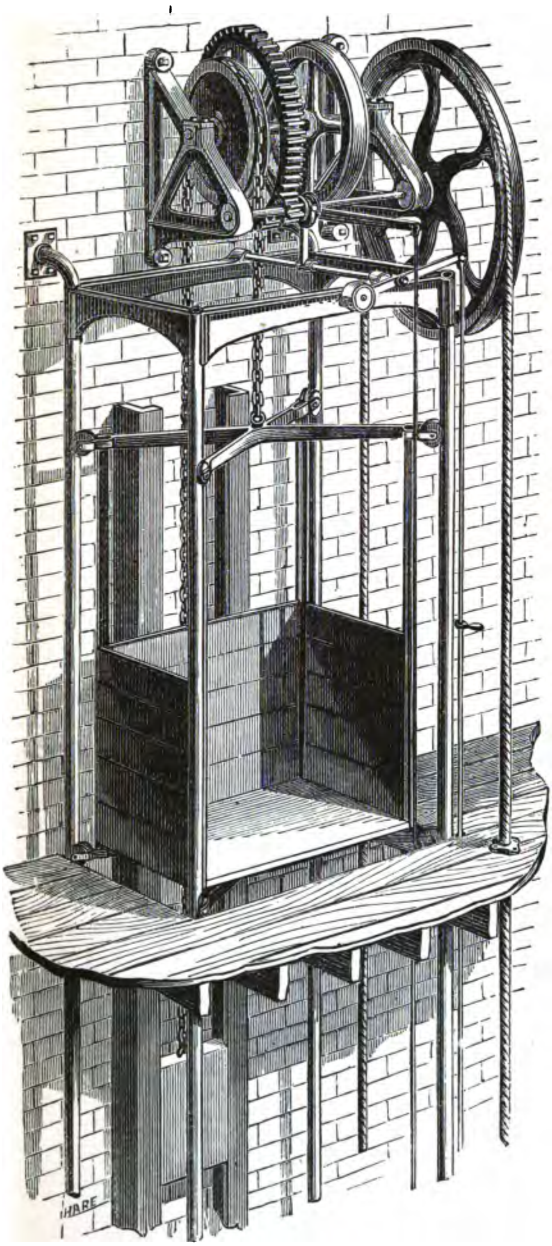


Fig. 172.

Fig. 172 is designed to fix against a wall; the guides are formed of tubes, and for lifts of small size and power this is a neat arrangement. The Illustration is taken from some lifts erected in 1863 in the then new premises of the London Printing and Publishing Company, and have been in work constantly ever since.

The power is obtained by the man hauling at an endless rope which works over a grooved wheel, the rope passing through all the floors, so that the lift can be wrought from any floor; this hauling wheel is keyed to a shaft which carries the pinion and brake: the brake is arranged so that it is always in action unless taken off by the attendant. The brake cord passes through all the floors alongside the hauling rope. The pinion gears into a spur wheel on the same shaft as the chain wheel, and the whole of the gearing is carried by a pair of cast-iron brackets.

The top of the guide tubes are supported by a neat entablature as shown, and the framing of the cage is constructed wholly of wrought iron lined with boards on three sides, either half way up or to the top; the lifts under consideration are constructed to carry loads of 10 cwt. The height is 20 ft. and the cages are 3 ft. 6 in. × 3 ft. 6 in. × 6 ft. high. The cost of the whole of the ironwork ready for erection is £40.

The Lift, Fig. 173, is the type usually adopted for larger sizes; the guides are formed of square timber firmly fixed at each floor line and to the bottom floor, the upper ends being secured to the tie beams of the roof or framed together to carry the gearing; this consists of a V wheel of large diameter, set in motion by the endless hauling rope. On the shaft carrying this wheel is fitted the brake and spur pinion, the latter gearing into a large spur wheel; the shaft on which this wheel is fixed also carries the chain or rope wheel over

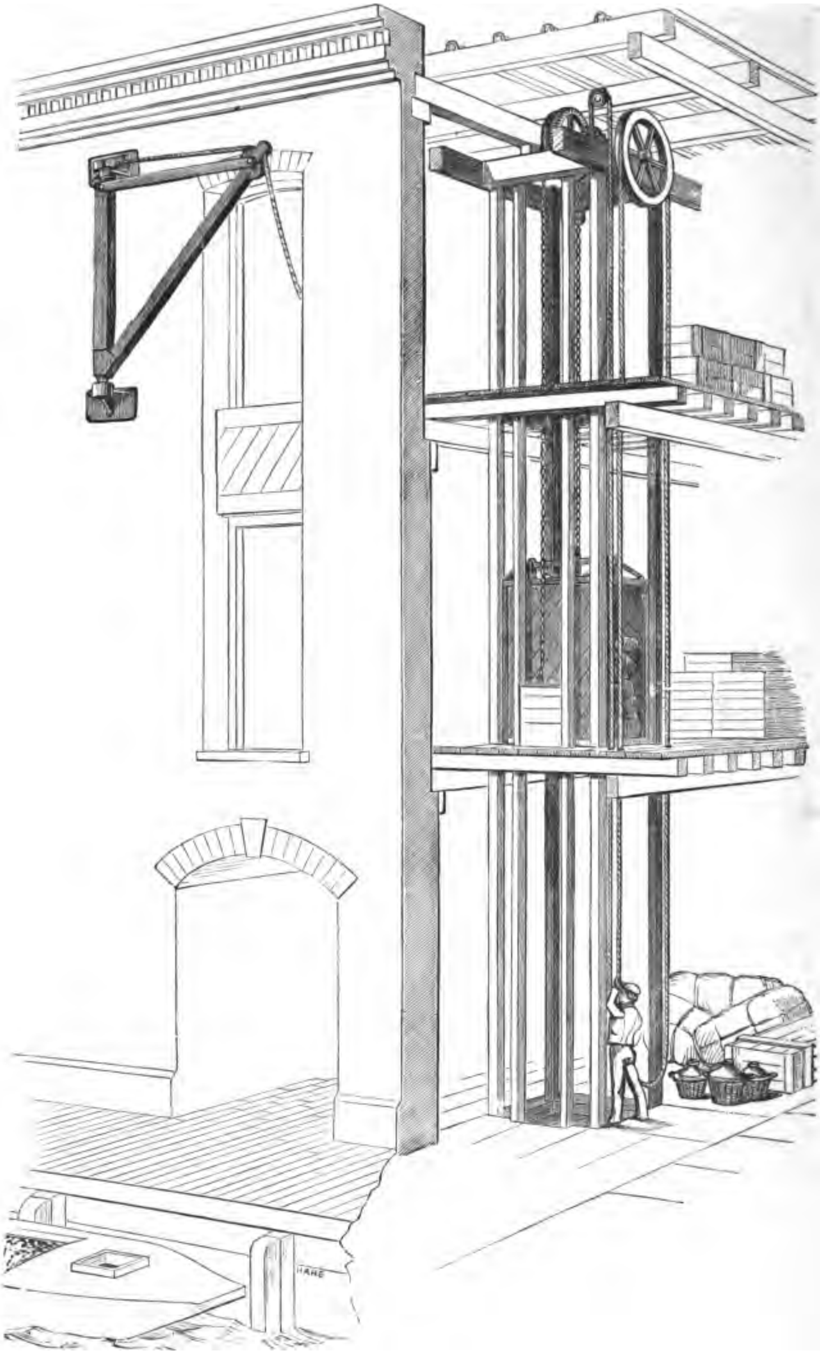


Fig. 173.

which passes the rope or chain, the ends being attached respectively to the cage and balance weight. This weight is generally made to counterpoise the empty cage and about 1 cwt. in excess, so that by releasing the brake the lift will ascend without the attendant hauling on the rope, and when lifting the maximum loads this arrangement reduces the work performed by the man to that extent, whilst it is particularly handy for lowering goods.

These Lifts can be fitted with a safety apparatus when required, which will arrest the cage from falling, should the rope break; the extra cost is given in the subjoined price list. It is often the practice to build a brick well-hole in warehouses, &c., for the Hoist or Lift, and when this is done, the cost of the timber work is considerably reduced; all that is required being a pair of timbers to form the guides, and two light grooved timbers for the balance weights which are fixed against the walls. This arrangement need not add much to the cost of the building, as a convenient angle may be chosen, or the outer walls of the building will serve to form two sides of the well. The size of cage given in the subjoined list of prices can be modified without increasing the cost, if the area remains the same—for example: a 4 ft. × 4 ft. cage = 16 ft. area; but the price would not be altered if the cage were made 5 ft. × 3 or 6 ft. × 2 ft. 6 in. The value of the ironwork and machinery is not affected to any considerable extent by the height of the lift, the only addition being so much more cage rope, brake line, and hauling rope.

Power of lift	5 cwt.	10 cwt.	15 cwt.	20 cwt.
Cage not exceeding 16 ft. area				
Height of lift not exceeding 40 ft.				
Price of ironwork and machinery, including ropes and chains	£45	£50	£60	£70
Price of ironwork and machinery, and timber framing, as shown	£60	£68	£80	£95
Price extra for safety apparatus	£10	£12 10	£15	£18
Approximate weight of ironwork	25	30	40	50
" measurement	35	50	75	90

LIFTS or HOISTS FOR CELLARS FOR HAND POWER. The Vertical Hoist, Fig. 174, is another useful machine, and is usually fixed in cellars having trap doors opening on the pavement, and so constructed that when the doors on the pavement are open, the platform will come up quite flush; a pit is made below the basement level to allow the platform to descend flush with the basement floor, so that goods, such as casks or bales, can be rolled on or off at each floor with perfect ease, and in some instances they are made to come up *above* the pavement or street and to the level of the tail-board of a cart or van, which gives an increased facility for moving goods in and out of store. This form of Hoist is shown worked by a hand-crab, but obviously it can be worked by power if desired. The varying conditions as to weight and height here again preclude the preparation of a list of prices and powers, but the Hoist illustrated was for a lift of 10 ft. in vertical height, the platform was 4 ft. × 4 ft., and the maximum load was 10 cwt.; the cost of the whole of the machinery was £45, including the crab, chains, and all ironwork, but not the cost of erection.

INCLINE CELLAR LIFT or HOIST, Fig. 175. In this case the steps from the basement to the street level are utilized to form the guides, and for light loads nothing more is required than a strongly-made step ladder; for lifts of greater power the sides of the steps forming the guides are of wrought rolled H iron, the inside being filled in with timber and notched for the steps. The platform of the lift is made to sink in a pit flush with the cellar floor, and the hoisting gear is generally fixed under it, so that when not in use the lift presents no more obstruction than an ordinary step ladder. If the necessary head room can be obtained in the front wall the platform can be made to run above the street level high enough to load into carts, &c., as described for the Hoists, Figs. 169 and 174. The incline lifts cost about the same as vertical lifts of equal size and power; they can be worked by power when desired, the Authors having fitted the well-known works of Messrs. Huntley and Palmer of Reading with both incline and vertical lifts worked by power.

DINNER or KITCHEN LIFTS, Fig. 176. The construction of these useful adjuncts for saving time and labour in hotels, restaurants, and private houses, is so clearly shown in the Engraving that but little description will be necessary; they are usually made with double boxes, so that one ascends whilst the other descends. The boxes are made of wood with movable shelves, and the only machinery required is a top pulley, spindle and bearings, and a rod to fasten the box when at the top of the lift. The lift is usually incased in woodwork, with sliding doors like window sashes. Speaking tubes are often carried from every floor to the

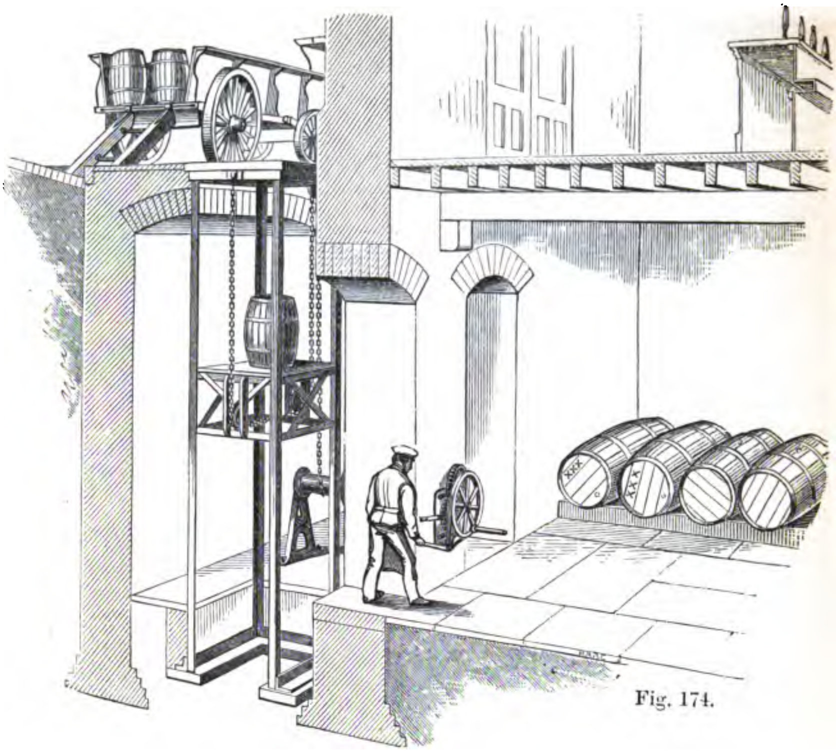


Fig. 174.

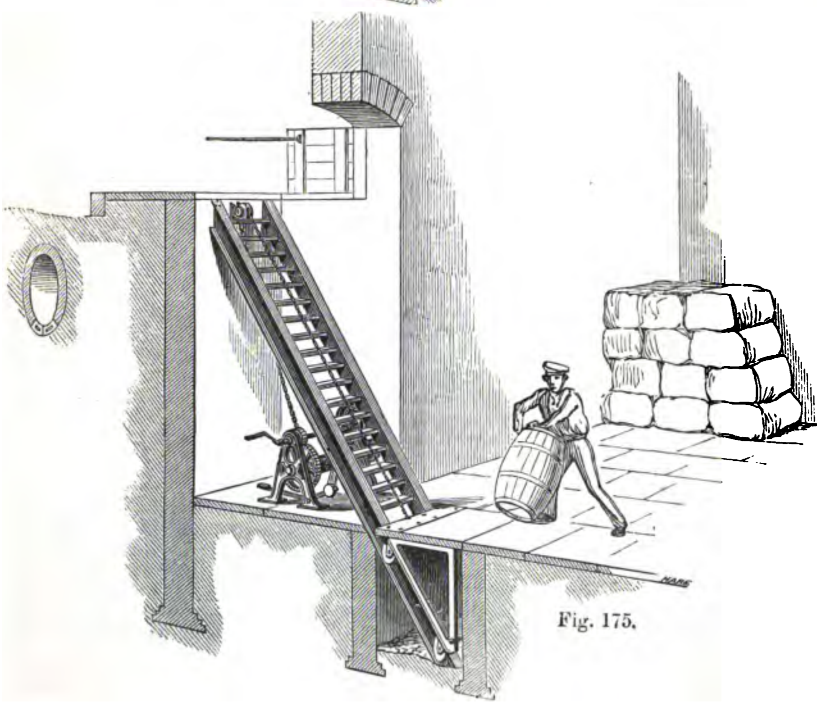


Fig. 175.

kitchen, and the cage or box is made strong enough to carry coals, &c., when the shelves are removed.

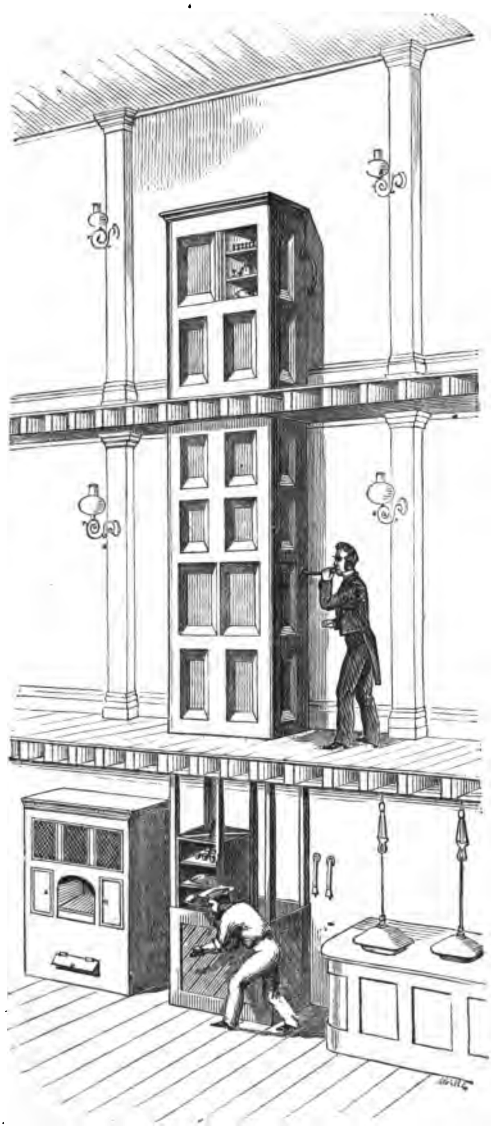


Fig. 176.

The mechanism is of the simplest possible character, and works almost noiselessly. The cost of the ironwork and machinery for a Lift constructed to carry 1 cwt., with up and down cages, is about £15, and it is usually erected by the builder to drawings supplied by the manufacturer; this work forming in fact part of the casing, which can of course be designed to correspond with the decoration of the room in which the opening to the lift is made.

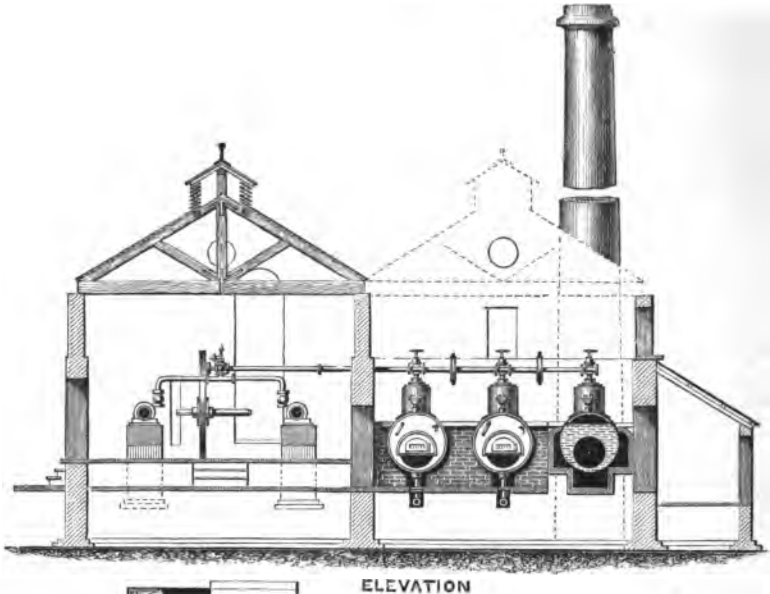
The cost of a dinner lift, with up and down boxes for plates and dishes only, is about £10.

WINDING ENGINES. The modern practice of mining engineers is to continually increase the size of the winding engines and speed of working; and there are many examples of colliery engines now in work which wind at a speed of 2500 ft. per minute, including stopping and starting.

This high speed of working can only be obtained by coupling the engines direct to a winding drum of considerable diameter on the engine shaft. A pair of horizontal engines, with the winding drums centrally between them, is the arrangement now usually adopted, as being economical alike in the cost of engines, foundations and buildings, and in working expenses.

The subjoined is a short description of two pairs of such engines, recently erected respectively at the Mapperley Colliery and at the Donisthorp Colliery, both in Derbyshire. A pair of horizontal engines with steam cylinders 24″ diameter × 48″ stroke are placed horizontally about 10 ft. 6 in. apart from centre to centre; the cylinders and valve boxes are neatly lagged, and fitted with condensed water cocks, shifting valves, and indicator cocks. The weight of the piston is carried by the piston rod being extended through the back cover, and both front and back glands are of ample length; the piston and valve rods are of steel, the guidebars are double, the bottom bars being cast on the beds and planed out to form oil channels, in which work the guide blocks which are of great length; the connecting-rods are of wrought iron got up

Fig. 177.



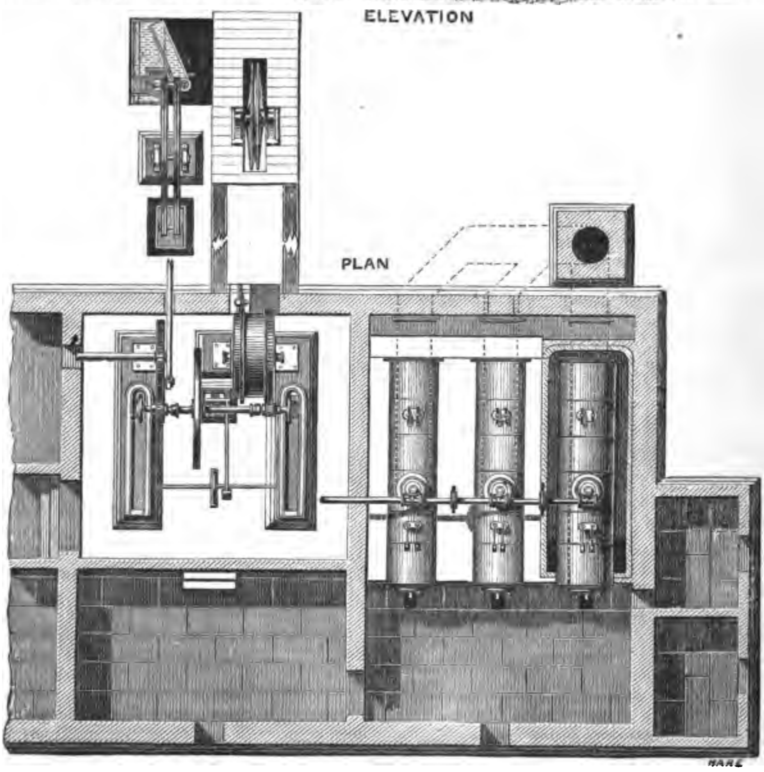


Fig. 178.

bright, with solid ends at the crank-pin end and strap and cotters at crosshead end; the length is 10 ft. from centre to centre, and both ends are fitted with hard gun-metal adjustable bearings; the cross-heads are of wrought iron forged solid and keyed to the rods with steel cotters. The cranks are of the overhung kind of wrought iron, forced on the ends of the main shaft, and keyed with two sunk steel keys at right angles. The valves are three ported, and are worked by a shifting bar link, the valves being balanced on the backs so that the driver can handle them with perfect ease when under pressure. The eccentric straps are lined with gun metal.

The crank shaft is of wrought iron 11⅛ in. diameter, in the centre planed eight sided for staking on the winding drums. These drums are slightly coned from 11 ft. 6 in. to 12 ft. diameter × 5 ft. 3 in. wide, and are constructed of cast-iron rings in halves bolted together and hung by keys on the flats planed on the shaft. The break ring is cast to these rings and is fitted with wood blocks; the brake straps embrace the lower half, and the lever for putting on or releasing the brake is worked by the foot of the attendant. In some cases the engines have been fitted with an auxiliary steam brake, which can instantly be used if desired.

The whole of the steam and exhaust pipes are carried below the beds of the engines and below the engine-room floor, which allows the condensed water to drain from the cylinders, a matter of importance in intermittent working, and at the same time preserving a neat appearance in the engine room. The steam slide valve is balanced, and the reversing, steam, and brake levers are all brought together in one set of quadrant guide plates, and close to the foot brake. The tell-tale is worked from a light drag link and crank coupled to one of the crank pins, and drives a worm and tangent wheel, the wheel spindle being fitted with indicator and dial. The whole is mounted on a pair of massive and neatly-designed cast-iron bed plates.

These engines are supplied with steam by a range of four boilers of egg-ended form, 30 ft. long × 5 ft., and are fitted with furnace work and steam fittings of the most approved patterns, including double safety valves, float indicators, as well as water gauges, &c., steam stop valves and branches to put any boiler out of use, expansion joints between each boiler, feed-water valves and pipes with expansion joints. The boilers are fed by a vertical steam donkey with 6 in. diameter cylinder and 3 in. double-acting pump.

At the pit's mouth, where a large amount of refuse coal can be obtained without great cost, it is usual to put down egg-ended boilers as being the lowest in first cost, and the repairs are less perhaps than in any other form of boiler; but for similar purposes, Cornish and Lancashire boilers have been used with marked success, one instance of which will be noticed later on.

The rope used at this colliery is 1¼ in. diameter round steel wire rope, and the nett loads are about 20 cwt. The cages are of wrought iron fitted with safety apparatus, see p. 114. The head pulleys are 12 ft. diameter with wrought-iron arms.

The engines are raising 500 tons of coal per day from a depth of 120 yards, and the total cost of engines, boilers, and steam connections is £2000.

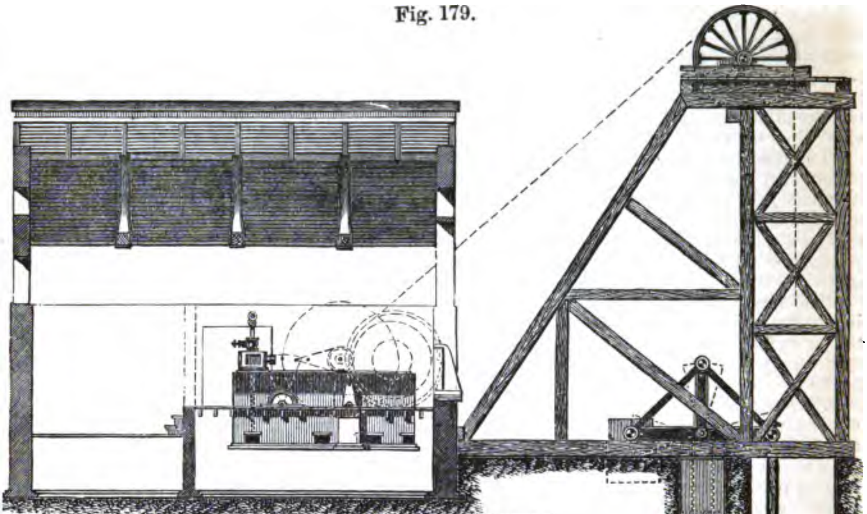
Winding engines for very deep shafts are sometimes fitted with condensers; but for shafts of moderate depth the intermittent nature of the work does not admit of a vacuum being obtained until just before the engines have to be stopped, and unless the vacuum is destroyed by a pet cock, or some similar expedient, the winding gear is rather difficult to manage; it is therefore exceptional to have condensers applied to winding engines.

A great contrast to the general practice of paying but little regard to the quantity or value of fuel consumed per ton of coals lifted, may be seen at the Blackwell Colliery, in Derbyshire, where the results are equal to anything and surpass many obtained in manufactories where the fuel costs three times as much as at the pit's mouth. The boilers at this colliery are double-flued Lancashire boilers, 28 ft. 6 in. long, and 7 ft. diameter; the flues are 2 ft. 9 in. diameter, contracted to 2 ft. 5 in.; each flue is fitted with four Galloway water tubes, and the grate surface in each tube is 16 square feet.

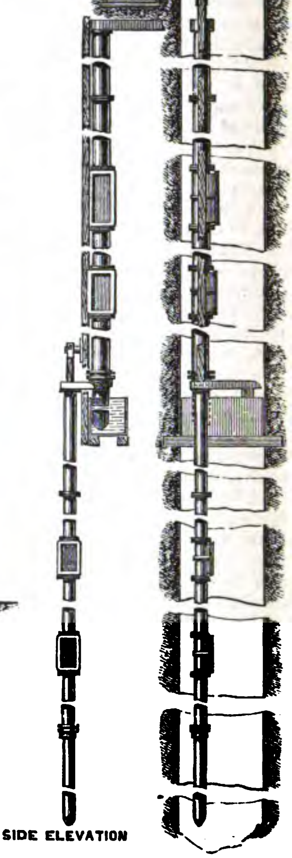
The boilers are set on Hydes and Bennett's system, which is, that the gases shall pass from the ends of the flues under the boiler, and then rise up through a series of fire-clay guides round the sides of the boiler as they pass along, and so into an overtop chamber which maintains the top of the boilers at an average temperature of about 550°, super-heating the steam to a useful and perfectly safe extent, whilst at the same time preventing loss from radiation, and admitting of the boilers being worked in the open air, as usually is the practice at collieries.

Considerable objection was raised to this method of setting, many persons maintaining that the top of the boiler would be heated too much, and cause leakage by expanding that portion more than the bottom; that the steam would be too much super-heated, and that there would be loss of strength from overheating. All these objections have, however, been best and most completely answered by the fact that plates tested by the Franklin Institute increased in tensile strength up to 570°, the strength being thus 66.500 lbs. per square inch against 56.000 lbs. at 32°, so that a greater strength is imparted to the boiler up to that temperature; and as to leakage from unequal expansion, the boilers in question have been in use six years, and are now quite equal to new, no repairs having been required to them under constant work for the last three years. Up to a given point super-heating is admitted to be of great value, and by adopting this system the cost of any kind of covering over the boiler is saved.

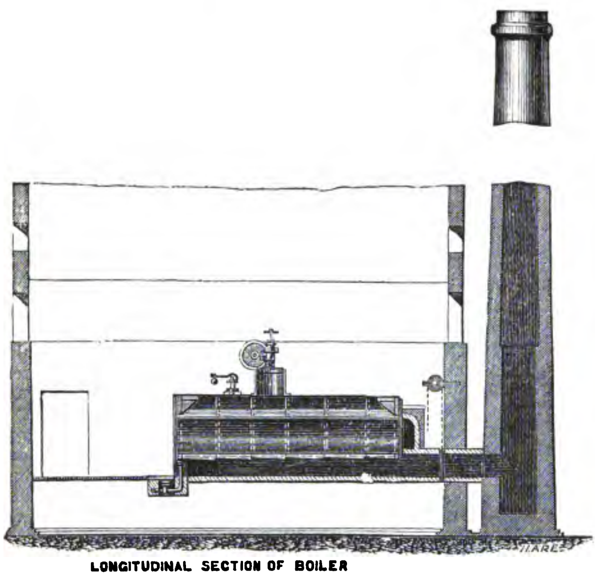
Fig. 179.



LONGITUDINAL SECTION OF ENGINE HOUSE



SIDE ELEVATION



LONGITUDINAL SECTION OF BOILER

Fig. 180.

The machinery illustrated Figs. 177 to 180, and Fig. 181, has been constructed for the Berlanga Silver Lead Mines in Spain.

The feed water is heated up to 220° before entering the boiler, and the form of water-heater used is an egg-ended receiver, about 20 ft. long × 5 ft. diameter, placed horizontally a few feet above the donkey pump. This receiver is fitted with a perforated plate about 18 inches from the top, on to which the cold water is discharged for the purpose of breaking up the stream whilst the exhaust steam is passing through the body of the receiver on its way to the atmosphere; the water thus falling through the perforations mingles with the steam and the temperature of the water is raised from about 64° to 220°. To prevent the heater from becoming choked with water, an overflow pipe is placed about 24 inches from the bottom of it. The boilers evaporate 466 gallons of cold water (64°) with 490 lbs. of engine slack per hour = 9.5 lbs. of water per pound of coal per hour, whilst the same boilers, with hot water from the water-heater at 190° (which is about the heat after being cooled by passing through the pump and pipes), working with the same coals, evaporated 10.42 lbs. of water per pound of coal. With hot water and best steam coals the duty was again raised to 11.21 lbs. of water per pound of coal, which is an excellent result to be obtained on an ordinary trial. Some other boilers were tested, set in the same manner, excepting they did not have the overtop chamber, and the best results from them, with Wigan coals, was about an average of 9.9 lbs. of water evaporated per pound of coal. It may also be interesting here to note that the test showed a consumption of about 21½ lbs. of coal *per ton of coals lifted* 720 *feet*, and that the horse power exerted was 341, whilst the power theoretically required to do the work is only 198 H.P., showing a loss from friction, &c., of nearly one half the power exerted even with engines and machinery of the highest class. The speed of working the 720 feet is 32 seconds, including starting and stopping, and the average during a day's work was 30 lifts per hour with up and down cages—four tubs in each cage.

The above data is taken from a very interesting Paper read before the Chesterfield and Derbyshire Institute of Engineers by Mr. J. A. Longden, the engineer and managing director of the Blackwell Colliery Company, and the same Paper contains full details of carefully-tabulated experiments by Mr. Longden.

Most large mines have separate pumping engines usually of the Cornish type, but for small pits the water can often be wound by a bucket alternately with the cage as shown in Fig. 182. Figs. 177 to 180 represent a plant of winding and pumping machinery constructed for a lead mine in Spain. Fig. 177 is an end elevation; Fig. 178 ground plan; Fig. 179 side elevation; and Fig. 180 section of boiler and boiler-house.

These engines are each 10 in. diameter × 20 in. stroke, fitted with link motions, and they are geared to a winding drum 6 ft. diameter × 2 ft. wide, with strap brake and foot lever; the pinion on the crank shaft can be thrown out of gear by a clutch and lever, so that the pump arm may be kept continuously running when the drum is out of use. The employment of gear instead of driving the winding drum or drums direct (as previously described), admits of the use of small engines for mines of considerable depth; and it is often very important that the parts should be exceedingly light, so as to allow of transport over bad roads and to almost inaccessible positions, saving in freight and carriage and immense risk.

These engines raise one-ton loads (total with cage) at 350 ft. per minute, and work pumps having a drawing lift of 8 in. diameter, and forcing lift of 10 in. diameter, to a height of 60 fathoms.

The arrangement is shown so clearly that there will be no need for much description; there are three Cornish boilers, each of 16 ft. long × 4 ft. 6 in. diameter, two boilers being sufficient to work the engines easily; the third being a duplicate, which could be laid off for cleaning when necessary.

The cost of the whole of the machinery and of the ironwork for the pit-head gear, including the wire ropes, pumps, tools for working engines, and to be used in erection, packed and delivered to docks, was £1640; the weight was 45 tons, and the measurement 1500 cubic feet.

Many other sets of winding and pumping engines of various sizes have been designed and made by the Authors, the smallest perhaps being a number constructed for the East Indian Railway Company, in which the steam cylinders were 8 in. diameter × 14 in. stroke, and the pump was 8 in. diameter × 14 in. stroke, double acting, fitted with 5 in. suction and rising main pipes. The boiler was of the semi-portable kind as shown in Fig. 181, p. 110. These engines were each fitted with two wrought-iron cages, ropes, head gear, safety apparatus to prevent over-winding, all the ironwork required for the pit-head gear, and the duty performed was to lift a nett load of 5 cwt. at 200 ft. per minute whilst pumping at the same time. The engines were constructed for working the thin seams of native coal, and as they are near the surface, the whole apparatus was made capable of being readily removed and re-erected as a seam was worked out, which was found to be more economical than to increase the underground workings. The cost of this plant was £600 per set. The total weight 16 tons, and the measurement 1200 cubic ft. These engines and pumps have given great satisfaction, and proved well adapted for the purpose.

A new form of engines was exhibited by the Authors at the International Exhibition of 1862, and during the last few years many winding engines of the type referred to, which is illustrated, Fig. 181, have been used with considerable success, especially for small mines and temporary workings. From the high pressure used in the locomotive boiler shown, the greater

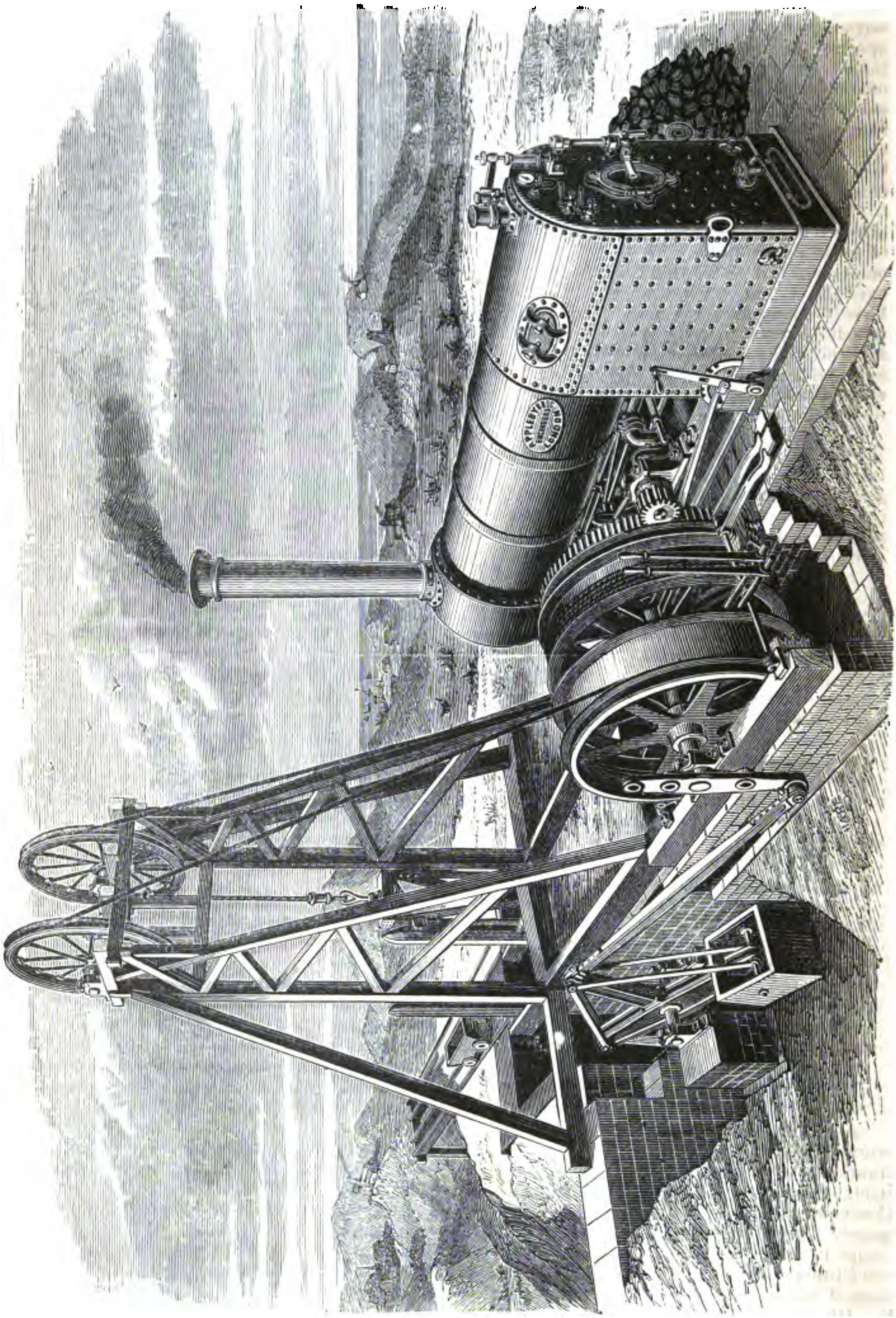


Fig. 181.

piston speed, and the high duty obtained from this form of boiler, together with the advantages which the construction offers in the facility for transport, erecting and setting to work without the delay and expense incurred in costly foundations, &c., render this form of engine specially adapted for use in countries where fuel is dear, and skilled labour to erect machinery is difficult to obtain. The cost of getting heavy machinery into position at the mines is often as much as the whole has cost in England; in such cases engines of this type compete successfully with the class of large direct-acting engines described as having been erected at Mapperley, &c.; but for great depths, and where fuel is of anything like moderate value, the large engines will unquestionably have the advantage, because the repairs on both engines and boilers will be so much lower, that this alone will probably more than cover the increased interest on the capital expended.

The arrangement shown in Fig. 181 was designed for use in Spain, where all the difficulties above referred to were encountered, both as regards cost of transport, erection, and the absence of building materials. In such cases the engine is, if possible, sent away erected complete, on its own bed plate, protected by a strong packing case. The boiler when lifted into position over the engine is ready to set to work when the necessary steam and feed-water connections have been made. The engine bed-plate is secured to a framework of wrought-iron girders, which carry the pedestals and bearings for the drum shaft, the brake gear, &c., is fixed in place, and the whole is tested in steam before being sent away; all parts are then carefully marked and numbered for re-erection on arrival at destination. The wrought-iron girders form a framework which cannot well be put together wrong, and the only foundation necessary is some rough stonework or solid level ground.

The wrought-iron girders are not included in the prices given in the subjoined list.

The prices do not include the head gear or timber work shown in the engraving, nor the wire rope, cages, or "bob" lever; the engines are made with the boilers fixed as shown, where great compactness is required; but as no other special advantage is gained by this, the boiler is frequently fixed a short distance away. The grit and dust from the stoking is thus removed further away, the engines are more accessible for cleaning or repairs, and the various working parts are kept cooler. The price is the same for either arrangement.

Nominal H.P.	12	14	15	20
Number and diameter of cylinders	2—8 in.	2—8½ in.	2—9 in.	2—10 in.
Diameter and width of drum ..	5′ 0″×1′ 6″	5′ 0″×1′ 6″	5′ 0″×1′ 6″	6′ 0″×1′ 0″
Weight lifted	15 cwt.	18 cwt.	21 cwt.	25 cwt.
Speed of rope per minute	500 ft.	500 ft.	500 ft.	500 ft.
Price with single drum	£450	£500	£540	£660
" double "	£475	£525	£565	£690
Price extra with pumping arm ..	£25	£25	£25	£30
Approximate weight	7 tons	8 tons	9 tons	10 tons
" measurement ..	720 cubic ft.	880 cubic ft.	950 cubic ft.	1050 cubic ft.

Nominal H.P.	25	30	40	50
Number and diameter of cylinders	2—11 in.	2—12 in.	2—14 in.	2—16 in.
Diameter and width of drum ..	6′ 0″×2′ 0″	7′ 0″×2′ 0″	7′ 6″×2′ 0″	7′ 6″×2′ 0″
Weight lifted	30 cwt.	40 cwt.	50 cwt.	60 cwt.
Speed of rope per minute	500 ft.	500 ft.	500 ft.	500 ft.
Price with single drum	£770	£900	£1150	£1350
" double "	£800	£950	£1200	£1400
Price extra with pumping arm ..	£30	£35	£40	£40
Approximate weight	12 tons	14 tons	17 tons	20 tons
" measurement ..	1200 cubic ft.	1400 cubic ft.	1700 cubic ft.	2000 cubic ft.

Another very handy form of winding gear is shown in Fig. 182. This is an ordinary portable engine, geared up to a winding drum placed on a couple of brick piers or a strong timber framing. A number of these engines have been made with the drums carried on the engine itself, these of course being readily removable if the engine is only required as a motor. Combinations of this kind are frequently of the greatest service to the miner, contractor, or quarry master. The head gear is here shown of cast and wrought iron; and as it is erected complete before shipment, the employment of costly labour abroad is unnecessary. In some cases timber can scarcely be obtained, and in others is not suitable for the climate; and in such cases it will be evident that a neat head gear, similar to that shown, offers many advantages. For Illustrations of small mining cage and tub, see section 5.

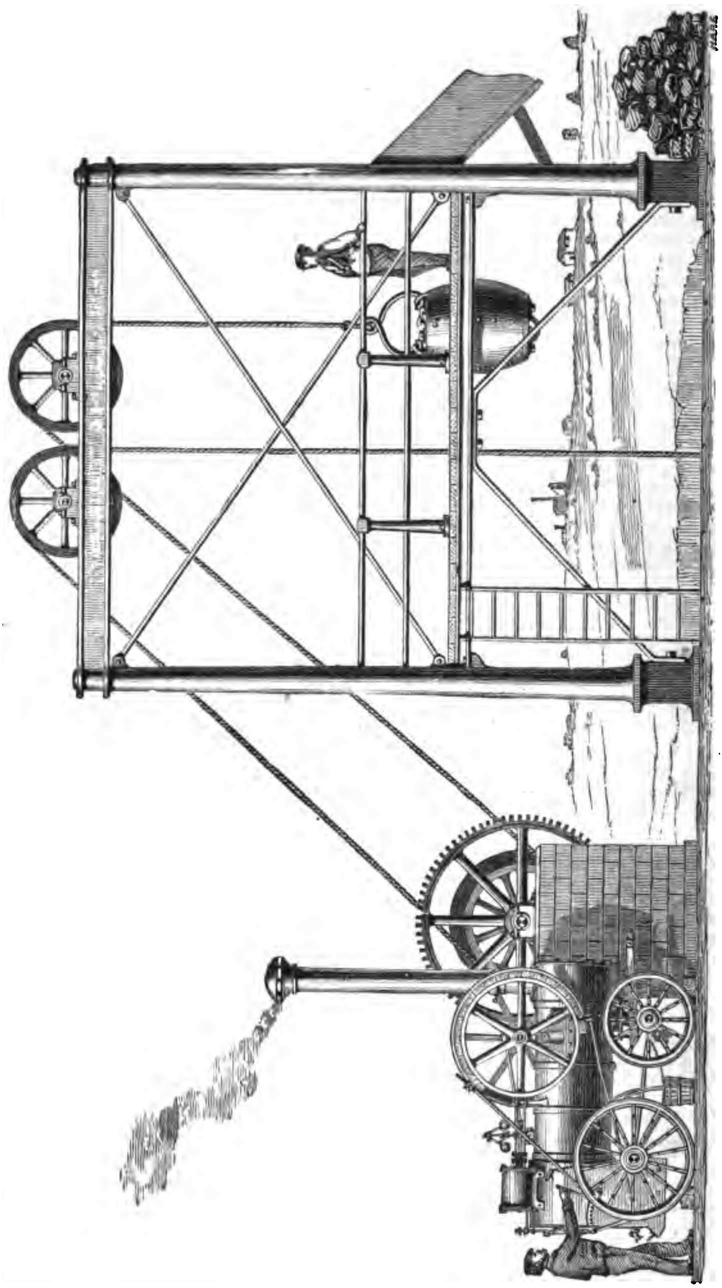


Fig. 182.

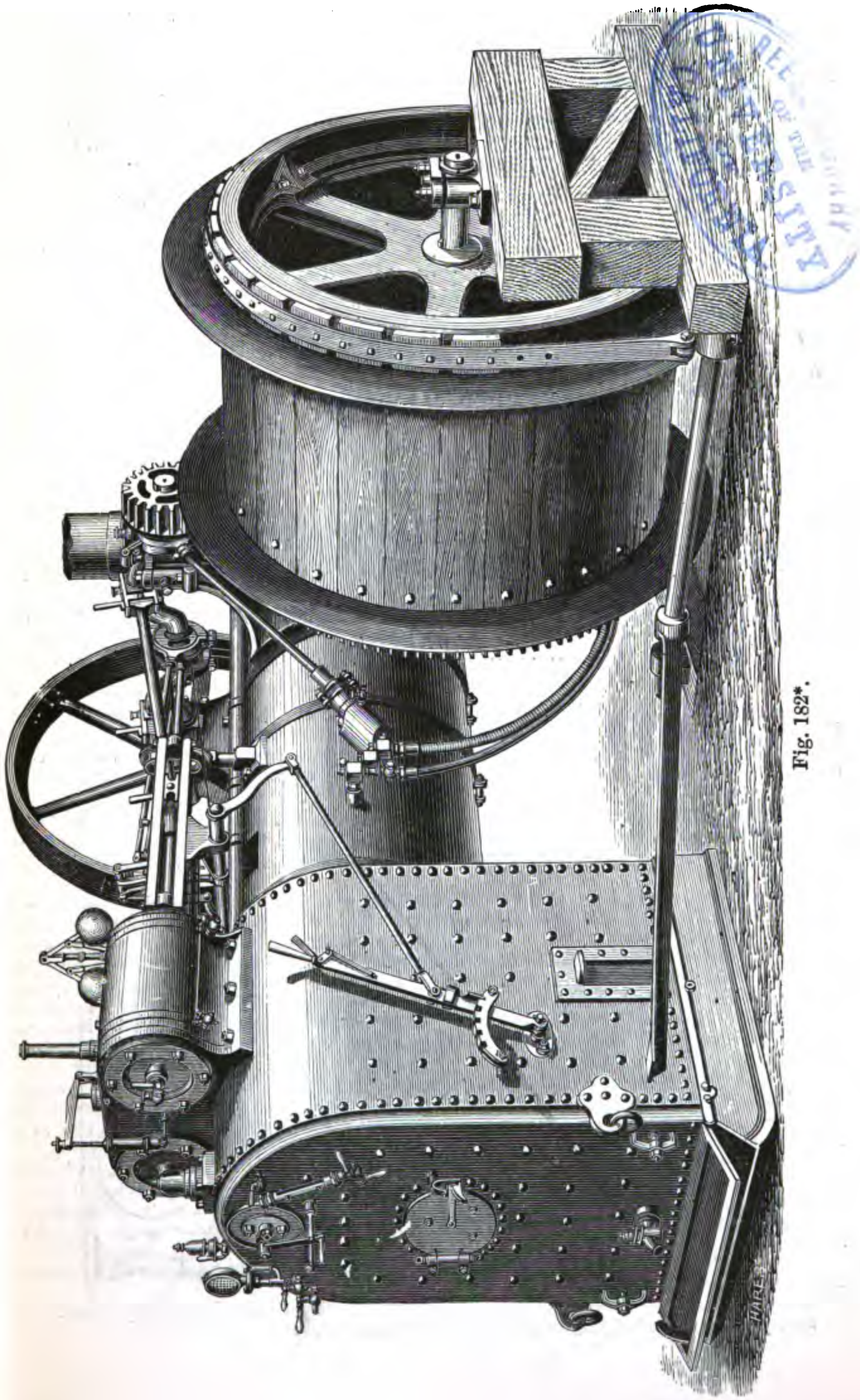


Fig. 182*.

Fig. 182* is an enlarged engraving of a double-cylinder portable engine of the ordinary type, without wheels or axles, geared to a winding drum mounted in a wood frame; an arrangement of this kind possesses nearly all the advantages claimed for that shown in Fig. 180, at a somewhat lower first cost.

Double drums with central clutches and separate brakes can be fitted instead of the single drum shown, when desired, so that two shafts of varying depths can be worked at one time; the extra cost of double drums is given in the subjoined price list, as well as a crank arm outside the plumber block for working pumps.

PRICES OF SINGLE-CYLINDER WINDING ENGINES, Fig. 182*.

Horse-power (nominal)	6	8	10	12
Diameter of cylinder and stroke	8½"×13"	9½"×13"	10½"×14"	12"×14"
Diameter of drum	4' 0"	5' 0"	5' 0"	5' 0"
Price	£280	£320	£380	£435
Extra for double drums	£20	£25	£25	£25
,, pumping arm	£10	£15	£15	£20
Approximate weight, in tons	4¼	5¼	6¼	7
,, measurement, in cubic feet ..	380	606	680	740

PRICES OF DOUBLE-CYLINDER WINDING ENGINES, Fig. 182*.

Horse-power (nominal)	8	10	12	14
Diameter of cylinder and stroke	6¾"×13"	7¾"×13"	8½"×13"	9½"×13"
Diameter of drum	5' 0"	5' 0"	5' 0"	6' 0"
Price	£260	£410	£430	£465
Extra for double drums	£25	£25	£25	£25
,, pumping arm	£20	£20	£20	£20
Approximate weight, in tons	6	7	7½	8
,, measurement	506	644	700	800

The speed of lifting, and weights to be lifted, can be modified to suit any conditions, but the usual speed is from 300 to 500 ft. per minute for loads of 10 to 20 cwt., and the steel wire ropes vary from ⅜" to ¾" diameter. The pit-head pulleys should be at least equal to the diameter of the drums given for each size, and are usually rather larger.

PIT-HEAD GEAR. The design of the framing for carrying the over-head gear varies considerably; in this country it is usually constructed of timber, but for shipment wrought-iron possesses many advantages, especially so where the climate is hot, or there is an absence of skilled labour.

A very neat and simple construction of over-head gear has been designed and made by the Authors for use in Spain and other warm climates. This consists of two main A frames made of wrought-iron of H section, those on the side nearest the engine (being line of pull) are the strongest. The frames are tied together transversely by lattice bracing, and are connected at their upper ends by horizontal girders, which carry the rope pulleys; a platform is provided around the top pulleys for oiling the bearings, &c., access to which is afforded by a ladder from ground level. The lower ends are fitted into strong cast-iron socket plates, which are secured to masonry or timber. The whole of the work is put together with bolts, so that the cost of freight is reduced to a minimum, and every facility is obtained for transport over difficult ground, and for re-erection at destination. The total cost, even in England, compares favourably with pit-head gears of the ordinary construction, but the advantage will be more apparent when the cost of freight, transit, erection, &c., are added, which form an important addition to the more bulky arrangement usually adopted.

The cost of these frames will be affected by the height, size of shaft, and power of engines employed; but a general idea may be obtained from the following data. A complete pit-head gear for 20 horse-power engine, 30' 0" high, fitted with two 6' 6" diam. pulleys with wrought-iron arms, spindles, bearings, platform, ladders, &c., costs £140, and one of the largest size about £250.

The cost of complete sets of ironwork for wood frames, including pulleys, may be taken at £40 to £100 per set according to size.

Wrought-iron cages £18 to £36 each. Safety apparatus for ditto about £30 per cage.

Safety hooks for preventing over-winding £10 to £15 each.

WINDING ENGINE FOR UNDERGROUND WORKINGS, Figs. 183 and 184. These engines are designed specially for working in levels and audits. Fig. 183 is a double-cylinder engine fixed on timber frame, and Fig. 184 is a single-cylinder engine mounted on low trolley wheels; but either can be made portable or fixed. The frames of the engines are made throughout of wrought iron; and everything is done to keep down the weight and bulk, and to adapt them for the rough usage they so often meet with underground, working in dirt and grit with but very little attention, the attendant rarely being a mechanic. Each engine is fitted with link reversing gear, double drums, separate brakes and clutches, so that the drums can be used quite independently of each other.

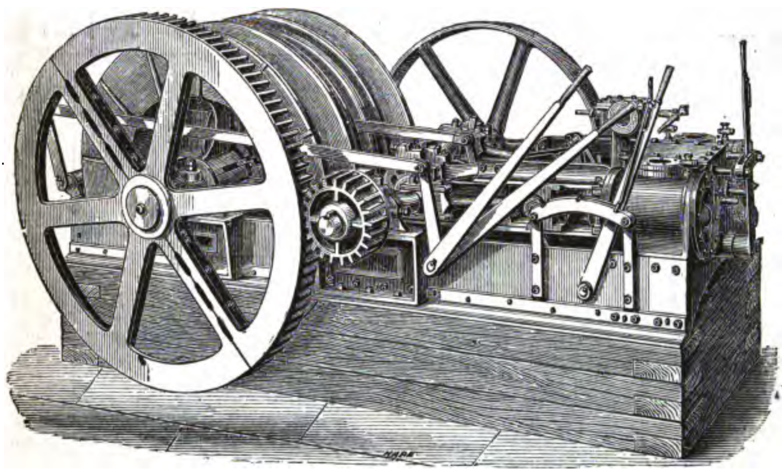


Fig. 183.

These engines are frequently driven by compressed air, and for that reason the powers have been calculated at 30 lbs. average pressure; but they are constructed to stand 80 lbs. pressure, and if steam be used the power developed will be in proportion to the pressure available. The clutches are all of wrought iron case hardened, the drums are bushed with gun metal running loose on the shafts, and the brakes are turned on their faces.

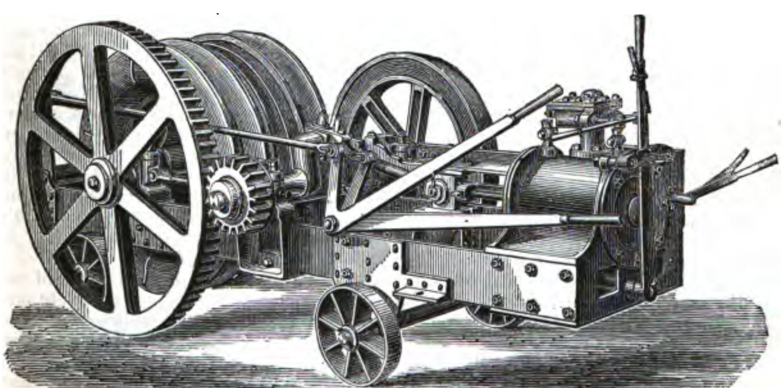


Fig. 184.

Prices and Dimensions of Engines, Figs. 183 and 184.

Nominal H.P.	8	12	14	12	16	20	30	40	50
Diam. and No. of cylinders	1—8″	1—12″	1—14″	2—8″	2—9″	2—10″	2—12″	2—14″	2—16″
Average steam pressure, lbs.	30	30	30	30	30	30	30	30	30
Diam. of wire rope	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.
Yds. of rope drums will hold	500	450	800	450	800	1000	1200	1250	2000
Speed of rope per min. ..	250 ft.	350 ft.	280 ft.	358 ft.	280 ft.	400 ft.	470 ft.	420 ft.	420 ft.
Weight lifted .. lbs.	1100	1800	2000	1600	2600	2200	2800	4000	5000
Price without wheels ..	£165	£225	£350	£350	£365	£400	£440	£565	£800
„ with wheels and axles	£175	£235	£365	£365	£380	£420	£465	£590	£825
Approx. weight .. tons	2	3½	4¾	4	4½	5	6	7	8
„ measurement in cub. ft.	100	150	200	200	220	250	280	320	350

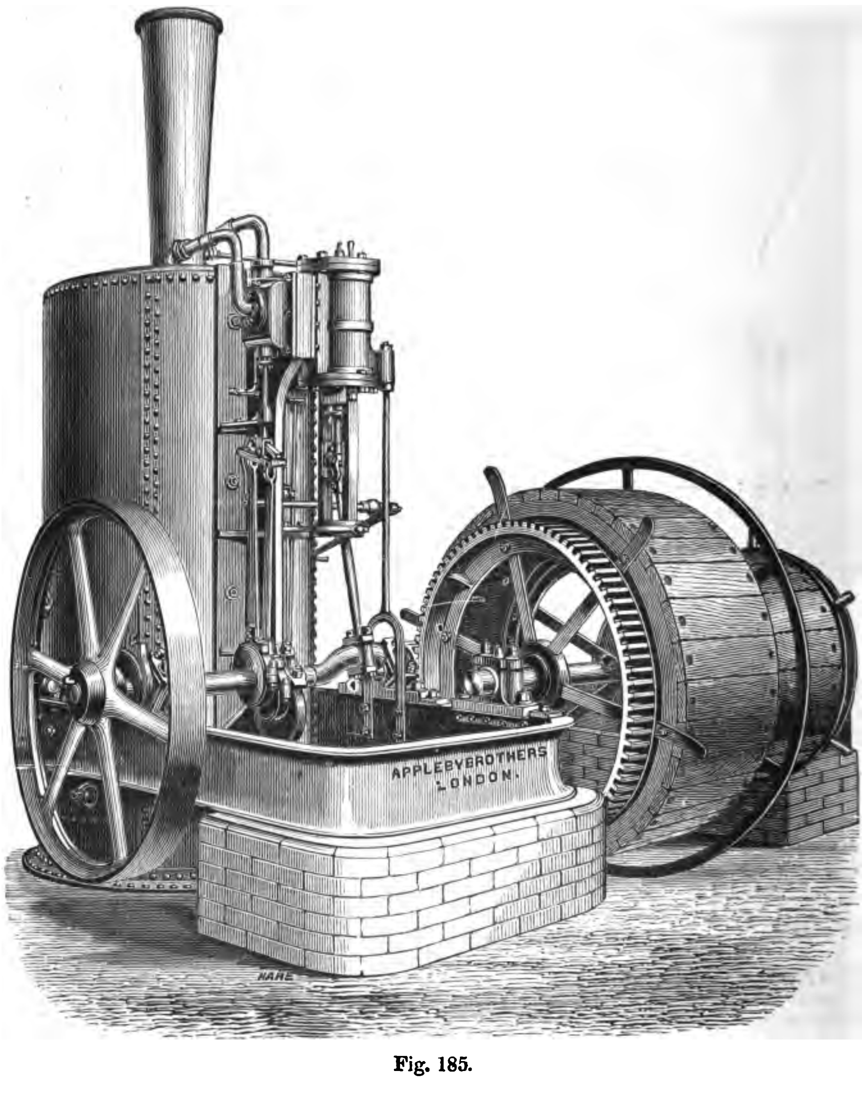


Fig. 185.

VERTICAL WINDING ENGINE, Fig. 185 (No. 16 c). In this arrangement the boiler is of the vertical type, with plain cross water tubes—a construction not to be recommended for economy in the consumption of fuel, but in practice it is a useful form of boiler, and will work with the worst kind of water without being deranged; a multitubular boiler working under the same conditions would soon become useless, or would be constantly under repair. The engine is vertical, and is carried by a casting which relieves the boiler from any strain. The crank shaft is of wrought iron with a central bearing, and the framing is constructed of wrought-iron channel bars, strong and light and neat in appearance. In this case the drums were placed outside the frame, and were made of different diameters in order to work two shafts of different depths at the same time.

The engine, Fig. 187, is similar to that described above, but the winding drum is placed inside the frame, and a pumping arm and shaft is added which can be worked at the same time or separately from the winding gear.

The cost of these engines is not much affected by the position of the drum, and separate prices are given for the extra shaft, bearings, and gear required to work the pumping arm. See list at pages 118 and 120.

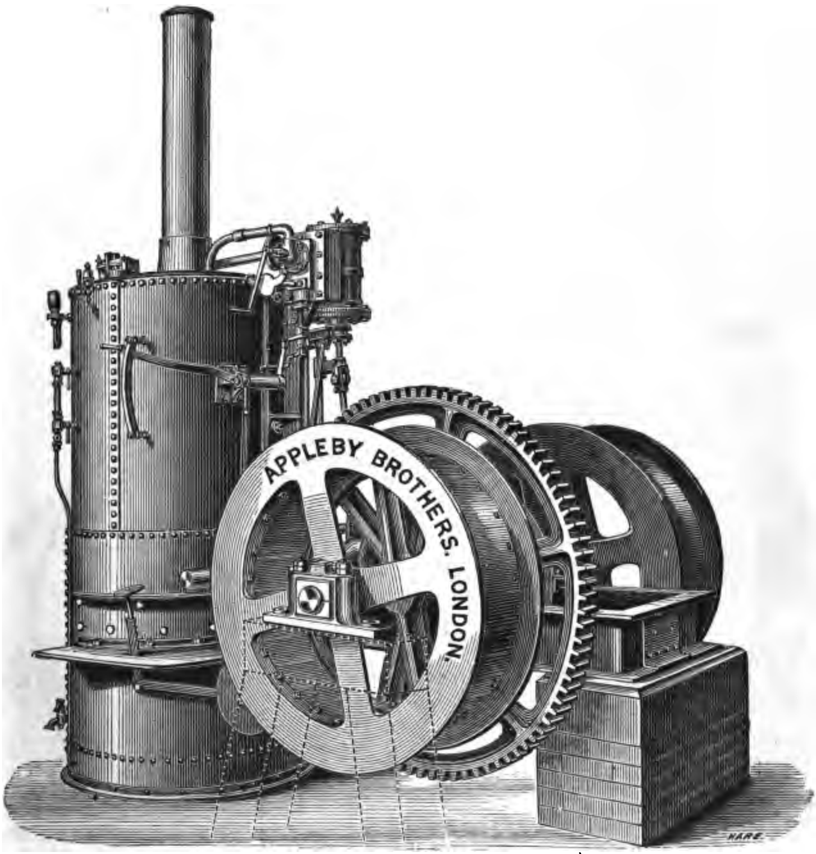


Fig. 186.

VERTICAL WINDING ENGINE with double drums, Fig. 186 (No. 16 D). The description at page 119 applies generally to this engine, the difference consisting in this having double winding drums outside the framing. The drum shaft is driven by a spur wheel, fixed centrally between the two drums, and controlled by one brake for working always together; they are also made with separate driving gear and brakes, so that one drum can be worked indepen-

dently of the other; outside bearings are provided for the ends of the drum shaft, which can be fixed on a timber frame as shown by the dotted lines, or on a brick or stone pier.

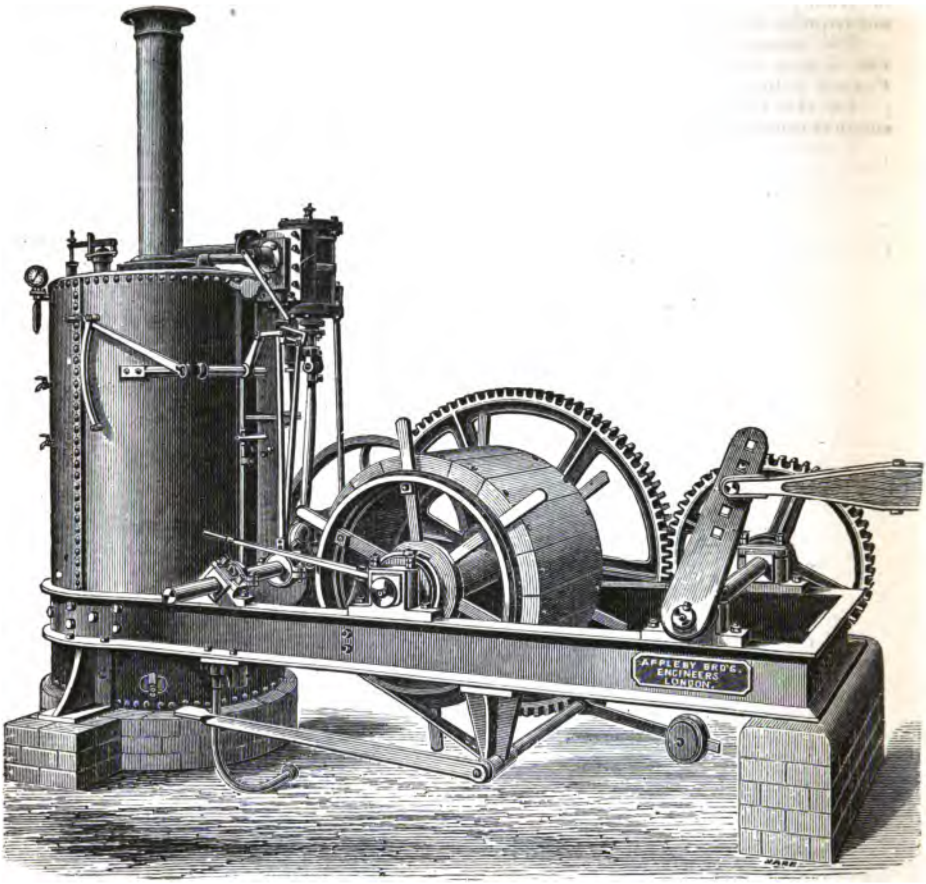


Fig. 187.

PRICES OF SINGLE-CYLINDER VERTICAL WINDING ENGINES, FIXED AND PORTABLE, Figs. 185, 186, 187, 189.

Nominal H.P.	3	4	6	8	10	12
Diameter of cylinder	5½ in.	6½ in.	7¼ in.	9 in.	10 in.	11 in.
Diameter of drums	3 ft.	3 ft. 6 in.	4 ft.	4 ft. 6 in.	5 ft.	5 ft.
Price	£165	£198	£220	£270	£305	£345
Extra with pumping arm	£5	£7	£10	£15	£20	£25
" double drums	£10	£12	£15	£20	£25	£30
" trolley wheels	£5	£8	£10	£12	£15	£18
" road wheel, locking plate and shafts	£10	£12	£15	£20	£25	£30
Approximate weight	3¼ tons	3¾ tons	4¾ tons	6¼ tons	7½ tons	8½ tons
" measurement ..	225 c. ft.	300 c. ft.	420 c. ft.	490 c. ft.	600 c. ft.	700 c. ft.

A crank pin for working pumps can be fitted into the main spur wheel without extra charge.

THE PORTABLE DOUBLE-CYLINDER WINDING ENGINE, Fig. 188 (No. 16 B), is mounted on wrought-iron road wheels, and is fitted with shafts and locking plate, and is easily moved from place to place like an ordinary portable engine. The drum and gear can be readily removed, and these engines are often used for driving machinery when they are not required for winding.

The construction is very similar to the fixed engines of the same type. The engraving, Fig. 188, is from a photograph of an engine of 12 horse-power, some of which were used by Mr. Firbank in the completion of the extensions of the Midland Railway in London.

Fig. 189 (No. 16 B) is a single-cylinder engine of same kind, but of 3 horse-power, the smallest usually made.

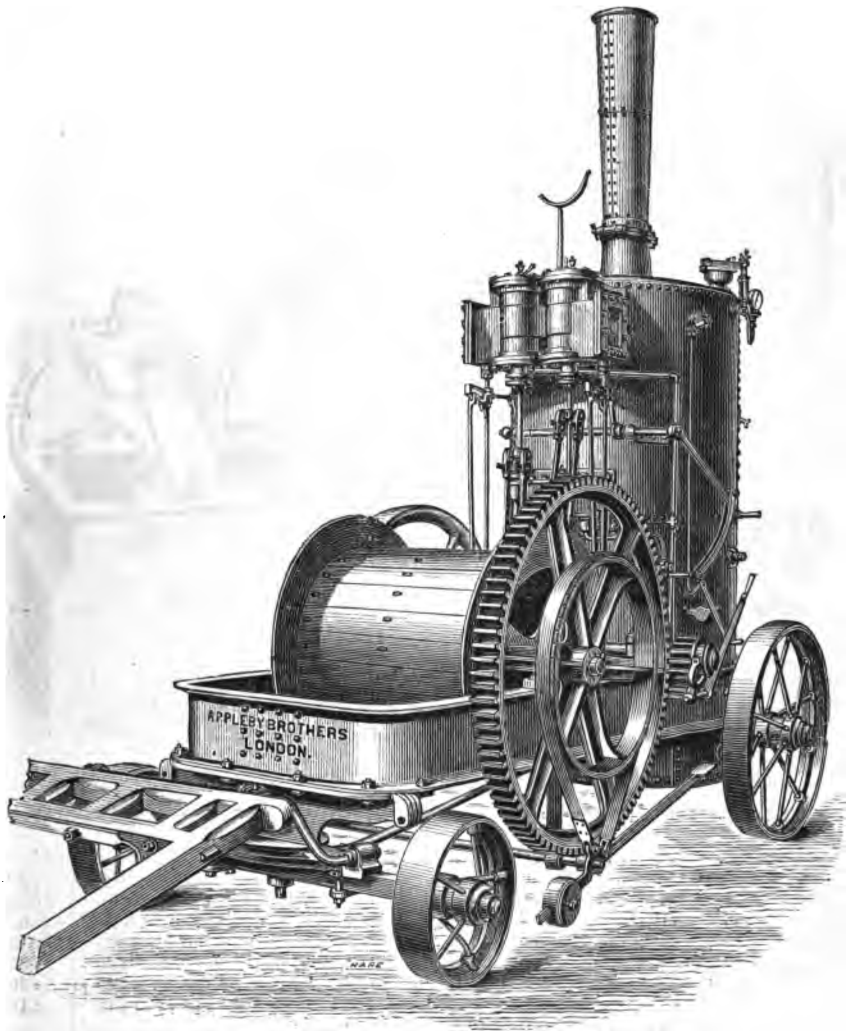


Fig. 188.

These engines are fitted with link reversing gear, so that an up or down cast or double rope can be worked, or lowering may be performed by steam or by the brake. The construction throughout is as light and strong as possible, and as engines of this kind frequently have to be transported great distances, and over the worst possible roads, wrought iron is used where

practicable, experience having shown that similar parts (such as drums, &c.) made in cast-iron frequently arrive at their destination broken, or so much damaged as to be almost useless.

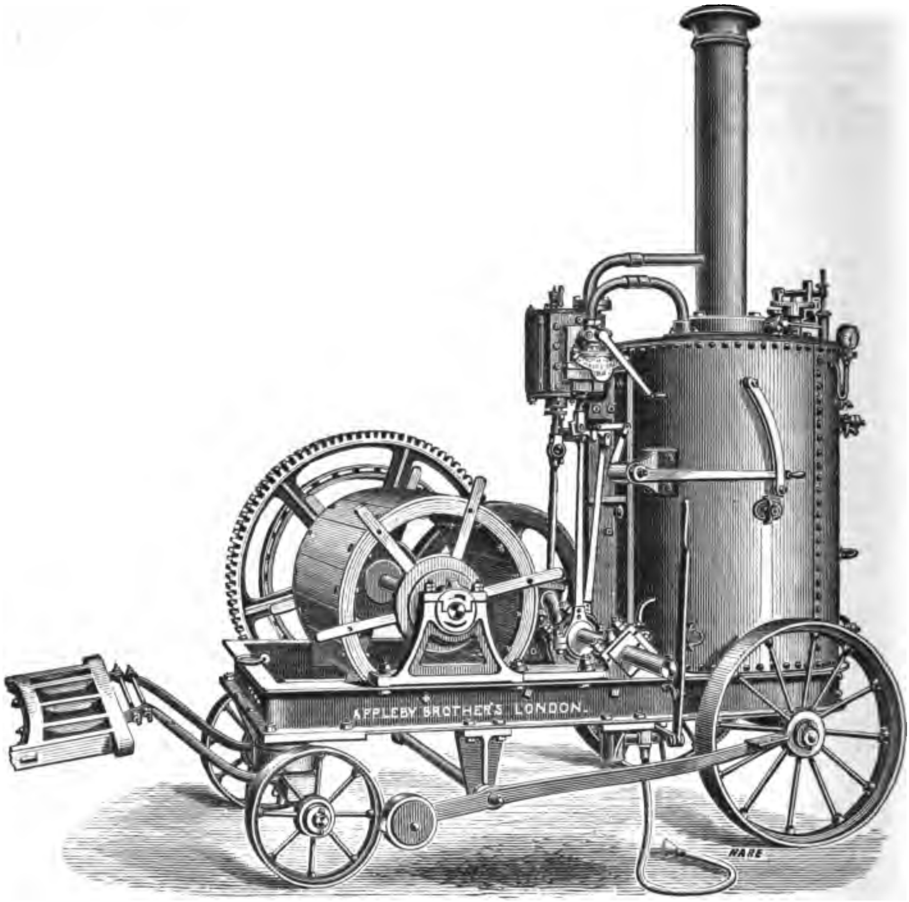


Fig. 189. (For prices see page 118.)

VERTICAL DOUBLE-CYLINDER WINDING ENGINES, FIXED OR PORTABLE, Fig. 188.

Nominal H.P.	6	8	12	16	20	24
Diameter and number of cylinders	2—5½ in.	—½ in.	2—7¼ in.	2—9 in.	2—10 in.	2—11 in.
Diameter of drums..	3 ft.	3 ft. 6 in.	4 ft.	4 ft. 6 in.	5 ft.	5 ft. 6 in.
Price	£265	£305	£375	£450	£560	£675
Extra price for pumping crank arm	£10	£15	£20	£25	£25	£30
" " double drums ..	£15	£20	£25	£25	£30	£35
" " trolley wheels ..	£10	£12	£15	£18	£20	£23
" " road wheels, locking plate, and shafts..	£15	£20	£25	£30	£35	£40
Approximate weight	5 tons	6½ tons	7½ tons	9 tons	10½ tons	12 tons
" measurement ..	430 c. ft.	500 c. ft.	600 c. ft.	950 c. ft.	1100 c. ft.	1200 c. ft.

If coals are used and the feed water is tolerably free from impurities, multitubular boilers offer some advantage in point of economy in the consumption of fuel, and the cost is about the same as for cross water tube boilers of equal power; but if wood fuel

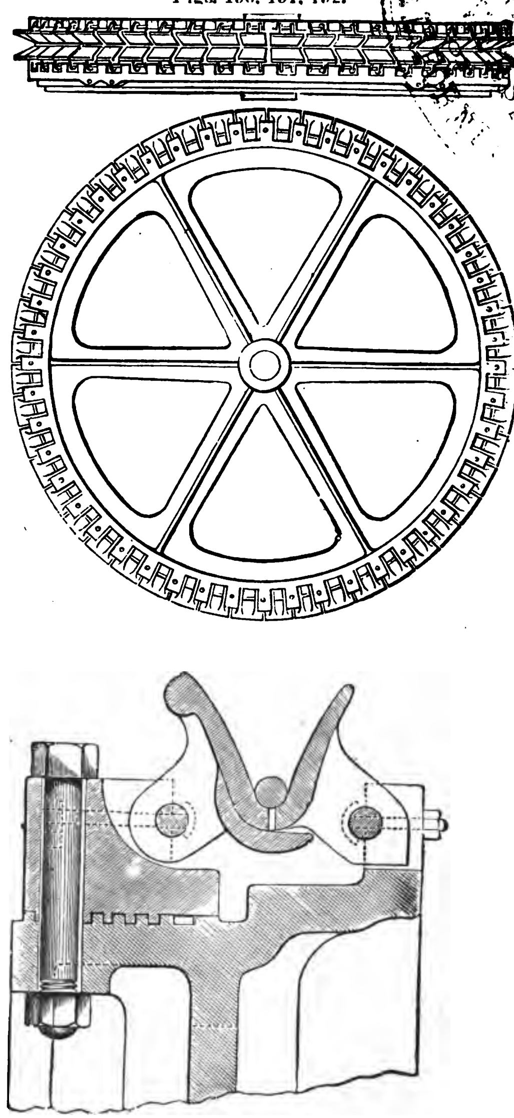
is used, the plain cross tube boilers are generally preferred on account of the larger fire boxes.

A very large number of these engines are in constant work in all parts of the world, and are giving the most satisfactory results.

MACHINERY FOR WORKING INCLINES. When the empty trucks have to be hauled up and the loaded waggons run down, a very simple and usual plan is, to have a wheel fitted with a number of forks, around one half of the diameter of which a common chain passes, the ends being attached to the waggons. This wheel is generally fitted on a vertical axis, in some cases above the ground, and high enough for the waggons to pass under it; and in others below the ground, to admit of trucks passing over it. The wheel is controlled by a brake which is fixed on the same axis or cast to it; often two brakes are supplied, either of them being sufficient to control the load, the duplicate being only used in case of accident; the two brake levers are brought side by side. This arrangement is largely used for underground haulage.

"FOWLER'S" PATENT CLIP PULLEY, shown in Figs. 190 to 192, is another method for working inclines by a round steel wire rope; the latter gives an enlarged section of the rim of the pulley, and shows clearly a pair of clips and the nipping action they have on the rope. This invention has been most successfully used for a great variety of purposes other than that indicated above. It is invaluable for transmitting power to a distance over ravines, rivers, &c., where intermediate supports cannot be obtained, for hauling boats on rivers, for ferries, driving overhead travellers, &c. The nipping action on the rope is always over at least half the diameter of the pulley, so that the wear on the rope is almost nil, the nipping action ceasing immediately and automatically the moment the rope begins to diverge from the circumference.

Figs. 190, 191, 192.



Prices of Patent Clip Drums.

Diameter of drum ..	3′.0″	4′.0″	5′.0″	6′.0″	7′.0″	8′.0″	9′.0″	10′.6″
Diameter of rope	$\frac{3}{8}$″ to $\frac{5}{8}$″	$\frac{5}{8}$″ to $\frac{7}{8}$″	$\frac{5}{8}$″ to $1\frac{1}{8}$″	$\frac{3}{4}$″ to $1\frac{1}{8}$″	$\frac{7}{8}$″ to $1\frac{1}{4}$″	$\frac{7}{8}$″ to $1\frac{3}{8}$″	1″ to $1\frac{1}{2}$″	$1\frac{1}{4}$″ to $1\frac{5}{8}$″
Working strain on rope, in tons	$\frac{3}{4}$	1—$1\frac{1}{2}$	1—2	2—3	3—4	4—6	5—8	6—10
Price	£25	£35	£50	£60	£75	£90	£125	£160

The winches referred to as having been used on the Exhibition Buildings in Hyde Park, 1851, were without engine power, and were driven by a strap from a portable engine, and they were not fitted with the chain barrels inside the frames.

Fig. 193 shows the application of the clip drum to a self-acting incline on which the loads are always going down, and Fig. 194 illustrates the action on an incline on which the loads are drawn up; in this case the clip drum must of course be driven from some motor, but in the former, a brake on the clip pulley axis is all that is necessary.

These pulleys will work either horizontally or vertically.

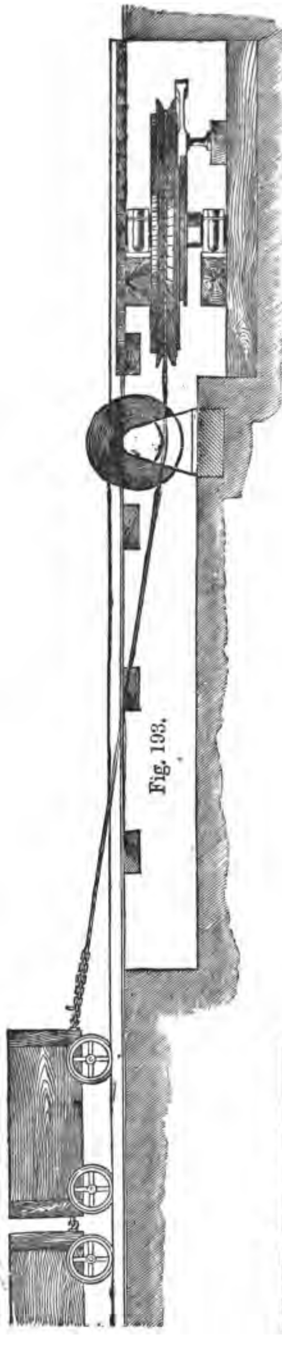


Fig. 193.

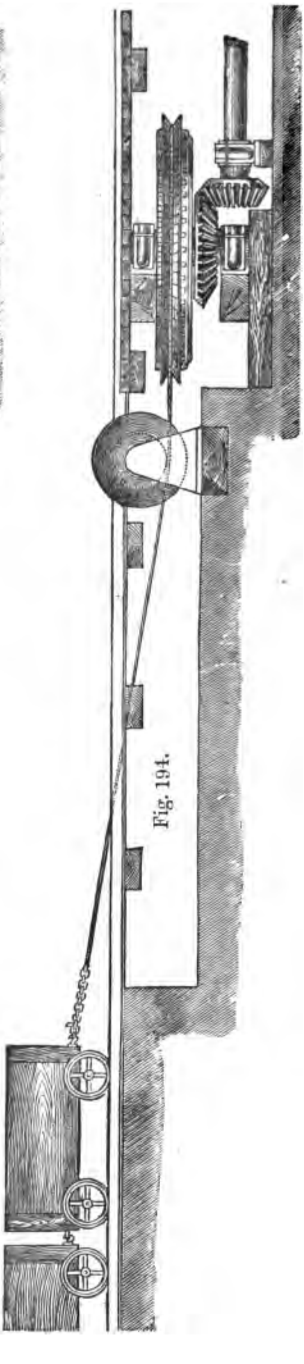


Fig. 194.

DUPLEX STEAM WINCH WITH TWIN DRUMS AND TWO CHAIN BARRELS. The winch illustrated had to fulfil the same conditions as those used in the erection of the columns and roofs of the Exhibition Buildings of 1851 and 1862, as well as the new Foreign Offices recently completed; but profiting by the experience gained on the works above named, the Authors designed and constructed the apparatus under consideration, for lifting the girders and iron work in the roof of the St. Pancras Midland Railway Terminus in London. The engraving is from a photograph which shows a portion of the staging employed in the work.

The apparatus is self-contained, and the two outside twin warping drums run at the same speed; but when these drums are not in use, either of the two chain barrels between (or inside) the frames can be used in either single or double purchase, and one may be lowering whilst the other is lifting its load. This result is obtained by using friction clutches to take the power from the engine shaft to the gearing, admitting of great facility of working and safety to the gearing, in consequence of the load being gradually put into motion.

The cylinders are on the outer side of one winch frame and at right angles with each other, the slide jackets being inside, and one pair of eccentrics work the two link motions; both of the connecting-rods are coupled to one crank pin in the large balanced disc-plate which is keyed on the engine shaft. Two pinions on this shaft flanged up to the pitch line, are always in gear with the large spur wheels, and they

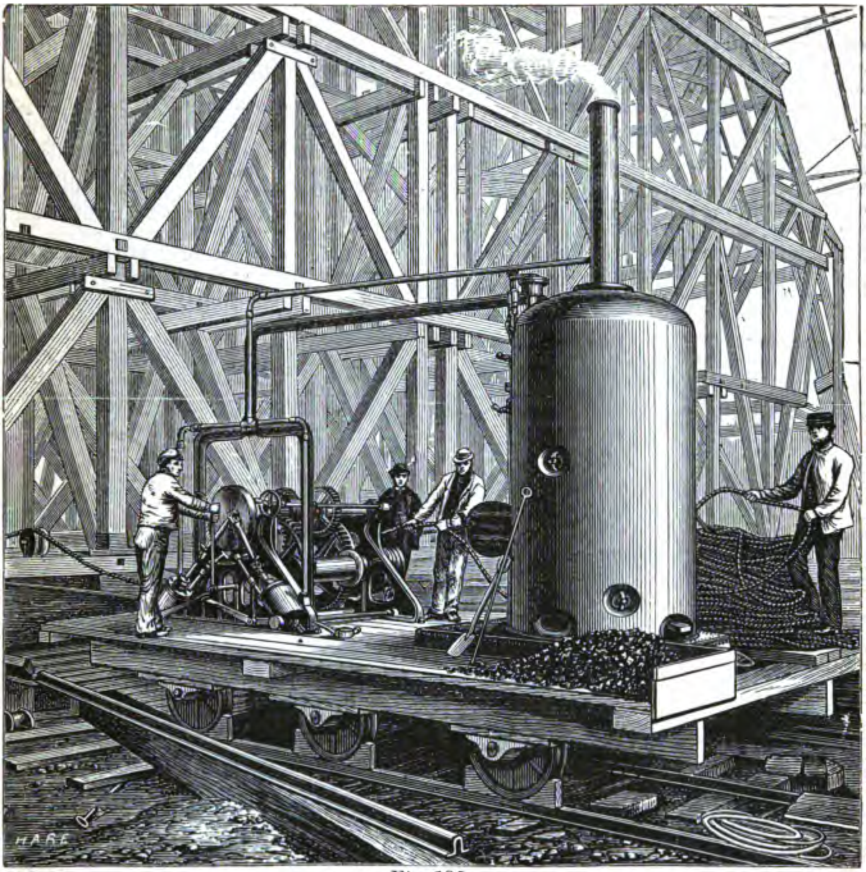


Fig. 195.

are made fast or loose to the engine shaft by friction clutches worked by screws and hand wheels; the double purchase is taken from two separate shafts, one for each barrel. The barrels are, as described above, inside the frames, and the shafts which carry them are left long enough to take the two warping drums for rope or chain; there is a connecting bar, or distance piece, with suitable bearings on the outer end of the shafts which carry the warping drums to distribute the strain on the drums equally between the two shafts. Each barrel is fitted with a separate brake strap and foot lever, and all the levers are brought close together to be within the control of the driver.

These winches are usually constructed to lift a maximum load of 3 tons direct from the barrel with a single chain, but they may be proportioned, and the Authors have made them to lift 6 tons or more without blocks; but as an almost unlimited length of rope may be used, and any amount of "nip" obtained by the use of the twin drums, it is perhaps preferable to use blocks for the heavy lifts instead of taking the power direct from the barrel.

The steam is supplied from a vertical boiler similar to that illustrated and described in Sec. 1, which, in addition to the usual furnace and steam fittings, has a steam feed pump, (see Sec. 3) and is fixed on a wrought-iron feed water tank. The whole is mounted on a travelling platform with flanged wheels to run on a 4 ft. 8½ in. gauge, and it serves two stages of the kind as shown in the engraving; six tackles (three to each staging) are carried to every part of the staging, and the platform can be moved in either direction by making a rope fast on either side and passing it round the warping drums. The engine power is also used for driving a punching and shearing and drilling machine, which are fixed on the travelling platform.

The approximate cost of the winch and boiler, with fittings and connections for steam supply and exhaust, is £300

Extra for wheels, axles, and ironwork for the platform £30

Or the travelling platform with winch, boiler and connection, complete £350

STEAM CAPSTAN, Fig. 196, was designed for use at Malta, and many of similar patterns are in use at all the Docks and Government Yards. The capstan is of the Admiralty pattern, and can be thrown out of gear with the engines, and manned by handspikes in the ordinary way if it does not happen to be convenient to run the engines.

The motor in this case was a steam engine, the steam cylinders being 5½-in. diameter by 10-in. stroke, with link-reversing motions; but these capstans are more frequently driven by a pair of hydraulic or water engines where that power is available. The gearing is single and double purchase, giving in the single purchase a pull of one ton on the hawser for light vessels, and in the double purchase a pull of 2 tons for vessels of greater tonnage; the engines and the whole of the gearing are placed in a masonry pit covered by chequered foot plates let in flush with the paving, which effectually protects the machinery from injury and from the weather, and provides the space around the capstan necessary for handling the hawser. Two socket levers working through slots in the foot plates put the capstan in motion; one being the reversing lever, and the other for changing the power or throwing the capstan entirely out of gear.

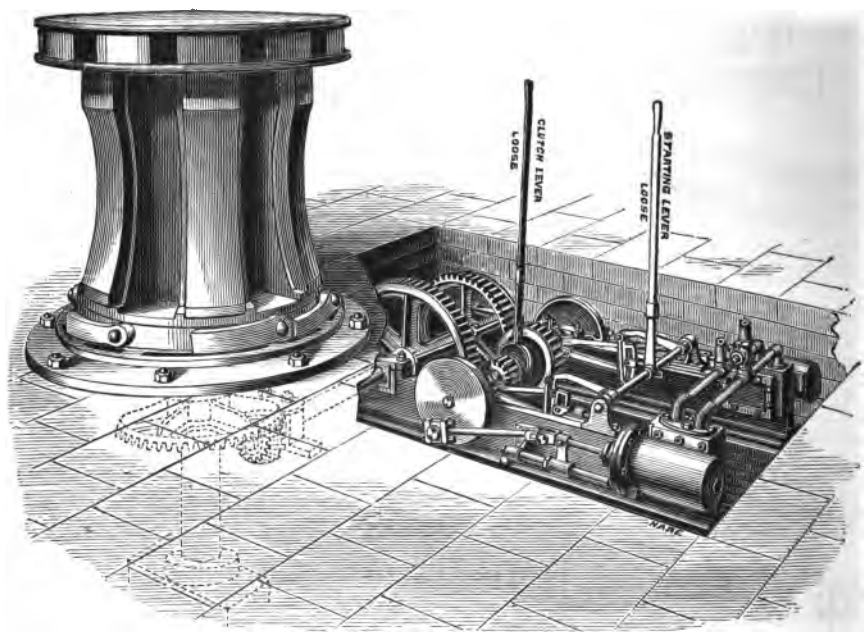


Fig. 196.

The vertical capstan spindle is of wrought iron, and the top step and other bearings are all of gun metal. Ample provision is made for lubrication, the bearing surfaces are large, and the machinery throughout is very strong and compact.

The price of this capstan ready for fixing is £265, and the weight is about 6 tons.

A similar form of capstan, but without the wooden welps, is much used in large goods depôts for shunting and turning trucks on the turntables, and a number of them are often driven from one steam or hydraulic engine by an underground shaft and gearing.

STEAM TRAVERSERS, Figs. 197 and 198. These traversers were designed and constructed for the Midland Railway Company, for use on their coal sidings, and they have been found to do the work of several horses with great economy in time and in working expenses.

The platform of the traverser in this case runs on a pair of sunk rails 11-ft. gauge which are at right angles to the sidings. The platform is constructed of three main wrought-iron girders strongly braced together on the bottom flanges, and chequered plates are rivetted on the top flanges. It is carried by three axles and pairs of wheels, each axle having three bearings suspended from the main girders. Between two of the axles, and at right angles to the main

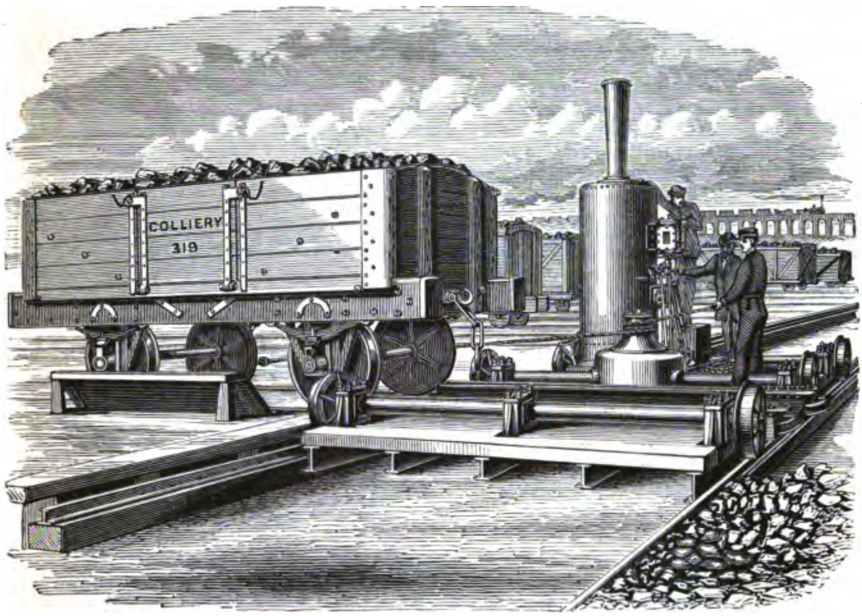


Fig. 197.

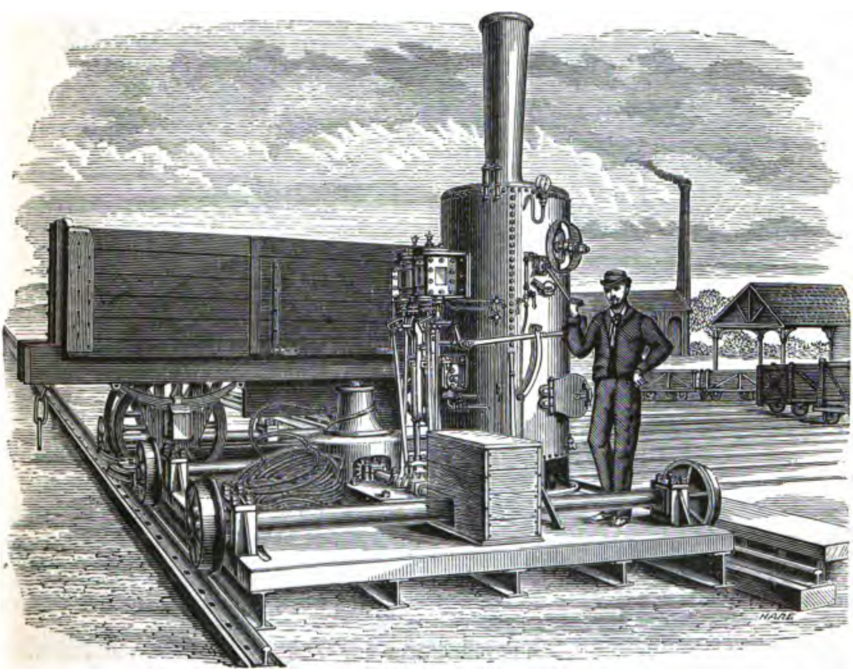


Fig. 198.

girders of the platform, are the trough-shaped girders and rails on which the trucks are placed, these of course being exactly level with the sidings, and the ends almost butting against them; the engines and boiler and travelling gear, also a vertical capstan driven by the engines, are fixed between the other axles.

The capstan is used for hauling the trucks on and off the traverser, and Fig. 197 shows a truck being hauled on. When it is on the traverser, as shown in Fig. 198, the travelling gear clutch is put on and the truck is traversed opposite to any siding; the tow rope is then hooked on to the back end of the truck, and it is hauled off by the capstan. The capstan is also used for shunting the trucks on the sidings in either direction by leading the tow rope around dummy heads which are fixed at convenient points between the various lines of rails. The same capstan is also used for swinging the turntables, &c.

The longitudinal travelling speed of the traverser is about 150 ft. per minute, and one traverser has shunted 20 trucks carrying 225 tons of coals (nett weight) into the various sidings in an hour; but the duty is necessarily somewhat affected by the distance the sidings are apart. The cost of working averages about 1*s.* per 100 tons moved, and the machine requires two men and a boy to work it.

Power of traverser in tons	14	18	30	40
Diameter of engines	$6\frac{1}{2}'' \times 10''$	$7\frac{1}{2}'' \times 10''$	$8'' \times 12''$	$8'' \times 12''$
Wheel base of truck or engine	9 ft.	9 ft.	12 ft.	14 ft.
Price	£550	£600	£750	£900
Price for housings	£35	£40	£50	£65
Approximate weight in tons	10	12	15	20

CAPSTAN WINDLASS FOR STEAM or HAND POWER. The application of steam power to capstans, for heaving the anchors of steamers or large sailing ships, is now almost universal, and the methods employed are very varied: one of the best arrangements consists of an ordinary capstan fixed on the huricane deck driven by steam, or it can be manned in the usual manner in case of need. The vertical spindle of the capstan passes through the upper deck and works in a footstep fixed on the next or main deck; on the same base plate as the footstep is fitted a pair of cast-iron side frames, which carry the necessary gearing, and a pair of steam cylinders for driving the windlass, motion being transmitted from the engine by bevel gear and worm and tangent wheel on the windlass axle. Two chain pulleys of proper size to suit the cable are fitted on each side of this worm wheel, and one or both can be connected to it by friction contact; each is provided with proper pawls and strap brakes, the engines can therefore be used either to work the chain cable, or to drive the capstan, or the capstan can be used by hand whilst the engines are lifting the anchors.

The advantage of this system is the easy manner in which the connections of the cable pulleys can be made by friction, so that if the ship surges heavily whilst heaving, the cable will slip to an extent sufficient to relieve both cable and windlass from excessive strain; worm and tangent gear is the safest for this purpose, as no slipping back can take place, and at the same time great power is gained in a very limited space. The following sizes are those generally in use, but any other size can be made.

Size of capstan windlass ..	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
„ chain cables	$2''$ to $1\frac{7}{8}''$	$1\frac{13}{16}''$ to $1\frac{11}{16}''$	$1\frac{5}{8}''$ to $1\frac{1}{2}''$	$1\frac{7}{16}''$ to $1\frac{5}{16}''$	$1\frac{1}{4}''$ to $1\frac{1}{8}''$
Diameter of steam cylinders ..	$9\frac{1}{2}$ in.	$8\frac{3}{4}$ in.	8 in.	7 in.	6 in.
Price, including pair of chain stoppers	£395	£345	£305	£265	£200
Approximate weight in tons ..	8	7	6	5	4
„ measurements in c. ft.	500	440	400	350	300

The anchor and cable of a 2000-ton ship can be lifted at 4 *to* 5 *fathoms per minute*, or the whole operation of lifting and fishing the anchor is performed in less than twenty minutes. These capstan windlasses are made of three designs in each size as follows:—with vertical engines and windlass between the hurricane and main deck; with windlass on upper deck and horizontal engines bolted up under the deck; with vertical engines, the whole of the machinery being on the same deck. The prices quoted are for either of the designs.

The smaller class of steamers and sailing vessels have the windlass driven by a messenger chain from the steam winch, the windlass being in that case fitted with a spur wheel in place of the worm wheel above described, and a pinion and countershaft which is driven by the

messenger chain; in some cases the whole is fitted on a pair of side frames similar to a steam winch without the capstan arrangement described above, and the prices are about 20 per cent. less than for those quoted.

PRICES FOR HAND-POWER CAPSTANS OF VARIOUS TYPES.

Size of chains	$2\frac{1}{16}''$ to $1\frac{15}{16}''$	$1\frac{7}{8}''$ to $1\frac{3}{4}''$	$1\frac{11}{16}''$ to $1\frac{5}{8}''$	$1\frac{9}{16}''$ to $1\frac{1}{2}''$	$1\frac{7}{16}''$ to $1\frac{3}{8}''$	$1\frac{5}{16}''$ to $1\frac{1}{4}''$	$1\frac{3}{16}''$ to $1''$
Price of plain double-deck capstan, with 2 riding bitts and 4 stoppers	£270	£190	£150	£130	£115	£98	£76
Price of plain single-deck capstan, with 2 riding bitts and 4 stoppers	£250	£170	£135	£115	£98	£82	£65
Price of single-deck steam capstan, with 2 riding bitts and 4 stoppers	£420	£285	£230	£200	£170	£145	£110

HAND-POWER WINDLASS WITH ROCKING LEVER PURCHASE WITHOUT CAPSTAN.

Size of windlass	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Price, including a pair of cable stoppers	£290	£250	£225	£200	£175
Approximate weight in tons	4	$3\frac{1}{2}$	3	$2\frac{3}{4}$	2
„ measurement in cubic feet	200	190	180	160	130

HARFIELD'S HAND-POWER CAPSTAN AND WINDLASS, Fig. 199, is used on board the largest ocean-going steamers, and by Her Majesty's Government, and is so well known that a detailed description is unnecessary.

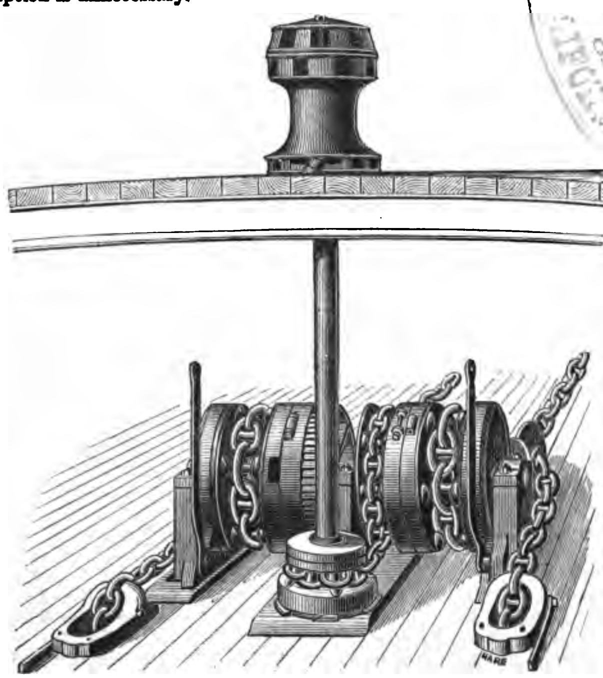


Fig. 199.

SHIPS STEAM HOIST, Fig. 200 (13B) and Fig. 201 (13C). The hoist, Fig. 200, has double steam cylinders with link reversing gear, which are fixed to a vertical boiler.

The lifting gear is single purchase, and is fitted with chain barrel, two capstan ends, chain wheels for messenger chains, and hand shaft; the whole being mounted on a wrought-iron water tank with low trolley wheels, the decks are protected from injury by heat and the ashes from the furnace. The hoist, Fig. 201, has the same engines, &c., as are above described, and

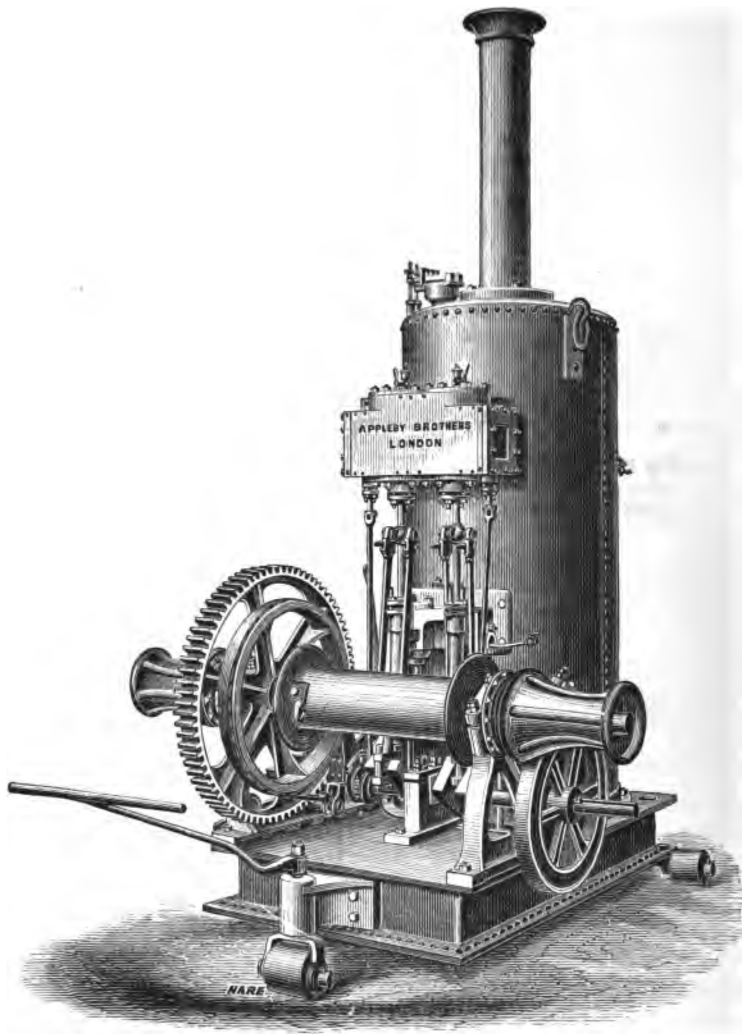


Fig. 200.

is fitted with a double-action pump, which can be used for pumping the bilge and washing decks, or as a fire-engine, also for circulating the water in the distilling apparatus which is shown. This is a most compact and efficient arrangement, and captains who have had the apparatus fitted on board have found that the total cost has been earned in the first voyage, in addition to the large saving in space and dead weight which is effected in ships carrying a fresh-water distilling apparatus, as by the order Gazetted Dec. 5th, 1875, passenger ships

carrying such an apparatus may sail with one half the quantity of fresh water which is required under the Passengers Act.

The pump can, with the attention of one man, do *continuously* as much work as the whole of the crew, and it is invaluable as a means of saving life and property in case of leaks or fire. The capstan can be used for setting sail, warping in and out of dock, &c., thus considerably reducing the labour and the number of hands required in these operations.

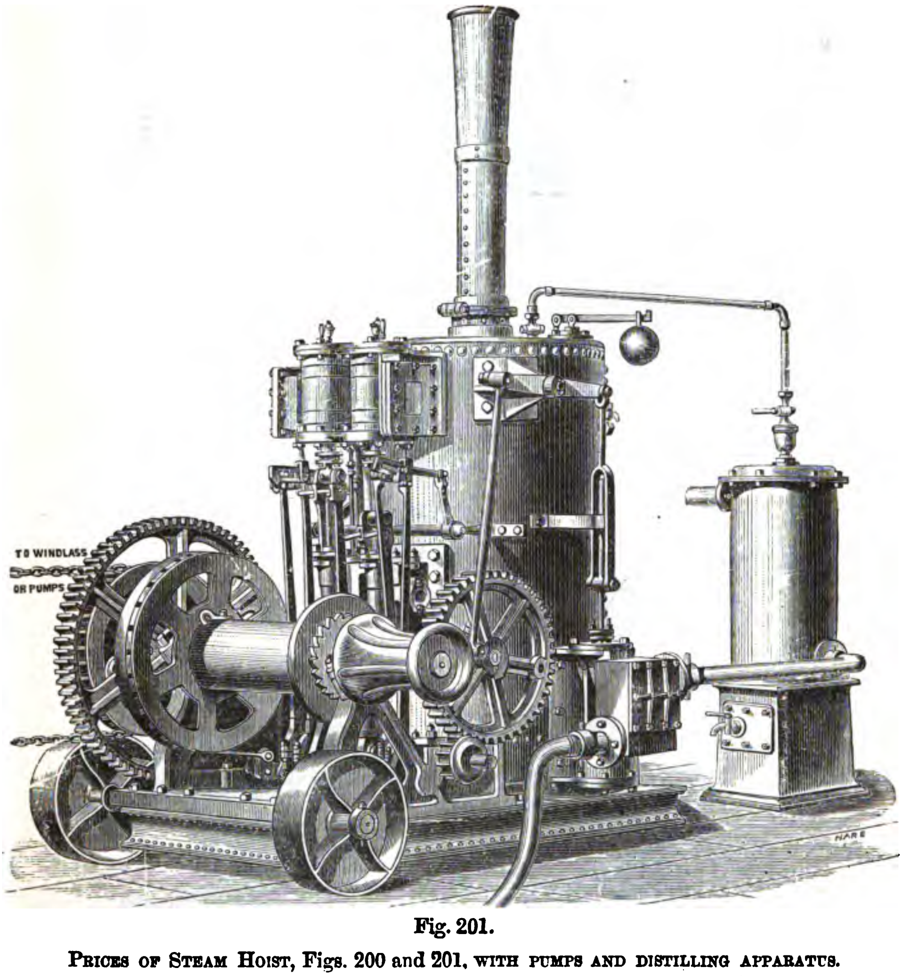


Fig. 201.

Prices of Steam Hoist, Figs. 200 and 201, with pumps and distilling apparatus.

Nominal H.P.	3	4	6	6	8	8	12
No. and diam. of cylind.	1—5½″	1—6½″	1—7¼″	2—5½″	1—9″	2—6½″	2—7¼″
Price, as Fig. 201 ..	£160	£180	£220	£230	£240	£275	£345
Size of pump	3″×9″	3″×9″	4″×12″	4″×12″	5″×12″	5″×12″	6″×12″
Price of pump and gear	£20	£20	£22	£22	£30	£30	£35
Capacity of distilling apparatus per hour ..	15 gal.	25 gal.	25 gal.	25 gal.	40 gal.	40 gal.	50 gal.
Price of ditto	£36	£36	£54	£54	£72	£72	£90
Approx. space in feet ..	5.6×5.0	6.0×5.0	6.6×5.6	6.6×5.6	7.0×6.0	7.0×6.0	8.0×6.6
„ weight in tons	2¾	3	3½	3¾	4½	4½	5
„ measurement in c. ft.	180	200	250	280	350	380	450

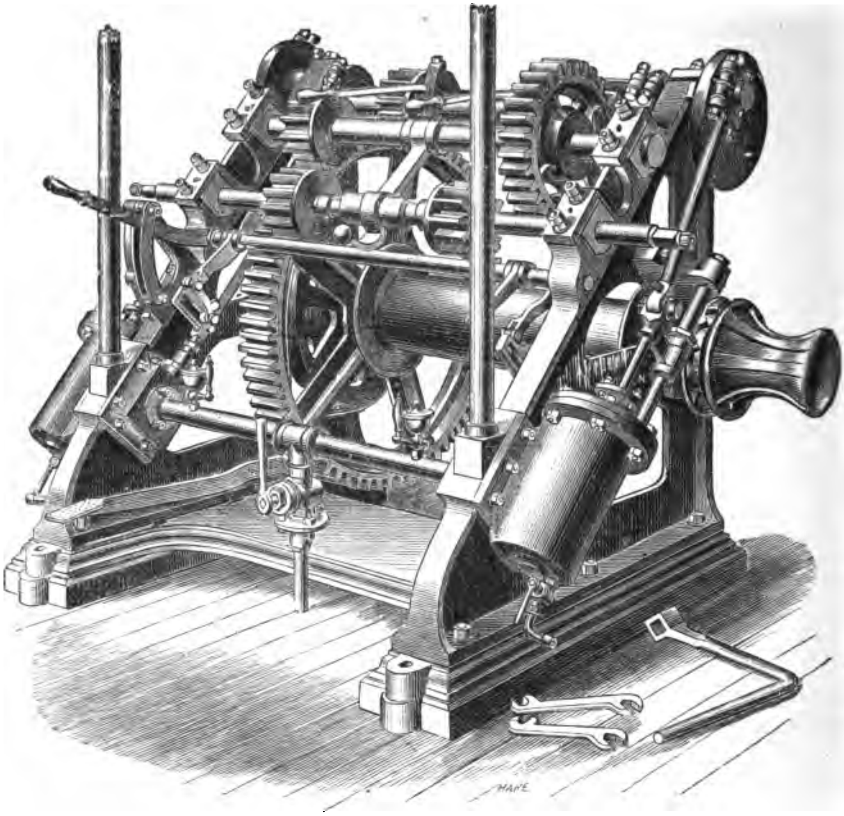


Fig. 202.

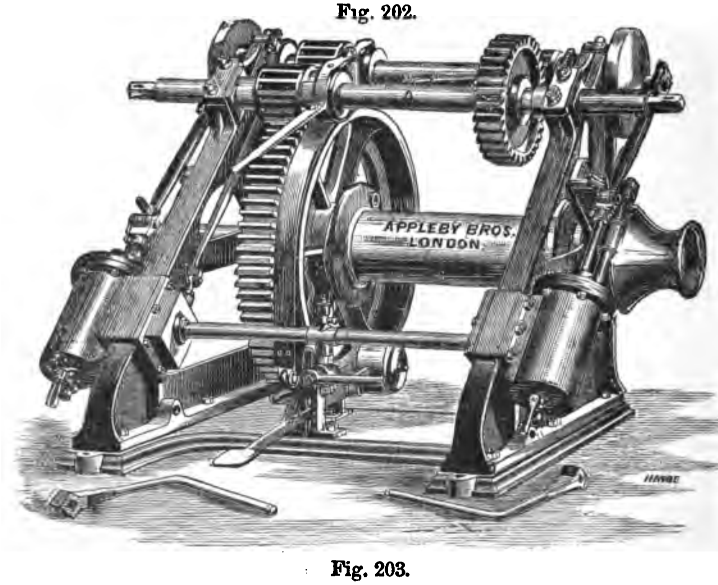


Fig. 203.

STEAM-POWER WINCHES. The engravings, Figs. 202 to 207, are examples of Steam Winches, for use on ships' decks, hoisting, pile-driving, &c., under various conditions. The first four are specially designed for ships' use, although they are employed for many other purposes. Fig. 202 is engraved from a photograph of a 5-ton winch, and is fitted with two steam cylinders, 8″ diameter × 10″ stroke, placed diagonally on the side frames to ensure a length of connecting-rod proportionate to the stroke. Winches of this kind are too often made with very short connecting-rods, and the result is a jerky motion on passing over the centres, and unnecessary wear and tear. The cylinders are bolted on the outside of the frames, and the slide jackets are on the insides, the steam ports being cast through the side frames to coincide with the ports in the cylinders; the pistons are fitted with metallic rings, steel piston and valve rods, gunmetal bushed glands, wrought-iron connecting-rods, marine-pattern gunmetal head at the crank-pin ends, and the solid ends at the crosshead ends are also fitted with adjustable gunmetal bearings; the disc plates are turned bright and balanced; the valves are worked by an improved link motion, with case-hardened blocks and pins and gunmetal eccentric straps.

The lifting gear is single and double purchase, and a separate hand-shaft is provided which can also be worked in single or double purchase. All the three high-speed shafts are fitted with heavy gunmetal bearings, loose caps, and lock nuts. The gear throughout is of extra width and strength, to withstand the rough usage to which these machines are subject. The large spur wheel is keyed directly on the chain barrel, and a brake ring is cast to it as large as can be got; it is turned on the face, and fitted with wood-lined strap and foot lever, with a pawl on the lever. The chain barrel takes a great length of chain, and is quite clear of any other parts of the winch, so that a fair lead may be obtained.

The barrel shaft is fitted with double warping ends, and messenger chain wheels for warping in dock, hoisting sails, &c., and the chain wheels are used for driving the windlass or pumps.

This winch can also be fitted with a pair of gunmetal barrel pumps on the same base plate. The pumps are driven from the second motion shaft, and the whole forms a very neat and useful arrangement. If a suction plate is added, the pumps can be connected with the various compartments of the ship, or be used as a powerful fire engine.

Fig. 203 is engraved from a winch of 3-ton power, and is not fitted with link motions, but lowers by break only. This is a cheaper arrangement, but is not recommended, because it is often essential to lower carefully by power, and in this case the link motion possesses many advantages; the double-purchase shaft serves for working by hand in the single purchase only; in other respects it is very similar to Fig. 204, excepting as regards proportion.

Fig. 204, ships winch of 2-ton power. The guides to the piston are cast to the steam cylinders, and *bored* out at the same time as the cylinder, ensuring perfect coincidence with the axis of the cylinder. This arrangement has been recently adopted, and the same kind of guides are now used for the winches Figs. 202 and 203.

Fig. 205 is a single-purchase winch, with one cylinder 6¼″ diameter × 9″ stroke, link motion, and single capstan end, interchangeable for fixing on either the engine shaft or the barrel shaft. With 45 lbs. of steam this winch lifts one ton, and is very useful for river craft or small vessels. Fig. 206 is the same winch fitted with double cylinders; and Fig. 207 is a double-cylinder winch of this pattern, with a vertical boiler connected up to it, and fitted with all the usual mountings, including steam donkey feed pump, and dead-weighted safety valve. This form of winch has also been employed for pile-driving, and is well adapted for that purpose (see Section 5). The small brake and clutch on the end of the barrel is specially for this purpose, and would not be required for ships or general use.

PRICES OF STEAM WINCHES, Figs. 202 to 204.

Power of winch in tons	2	3	4	5
Number and diameter of cylinders	2—5″×9″	2—6″×10″	2—7″×10″	2—8″×10″
Price of crab, Fig. 204, without link motions or third shaft ..	£70	£80	£95	£105
Price of winch, as Fig. 203, with link motion and extra hand shaft	£80	£95	£105	£120
Number and diameter of pumps ..	2—4″	2—4″	2—5″	2—6″
Price extra, if fitted with pumps ..	£35	£35	£45	£55
Approximate weight in cwts. ..	30	35	40	45
„ measurement altogether	100	130	150	175

The measurement is considerably reduced if the winches are taken to pieces for shipment; but what is saved in freight may probably be expended in the cost of erection at destination.

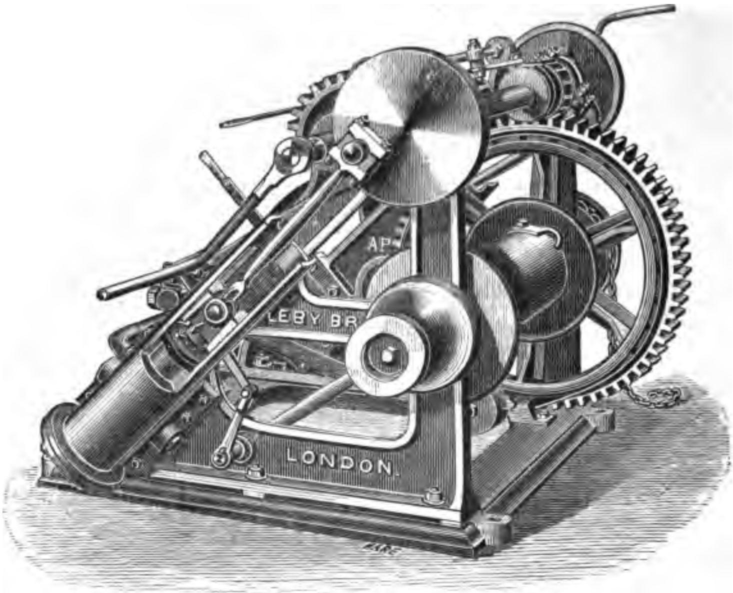


Fig. 204.

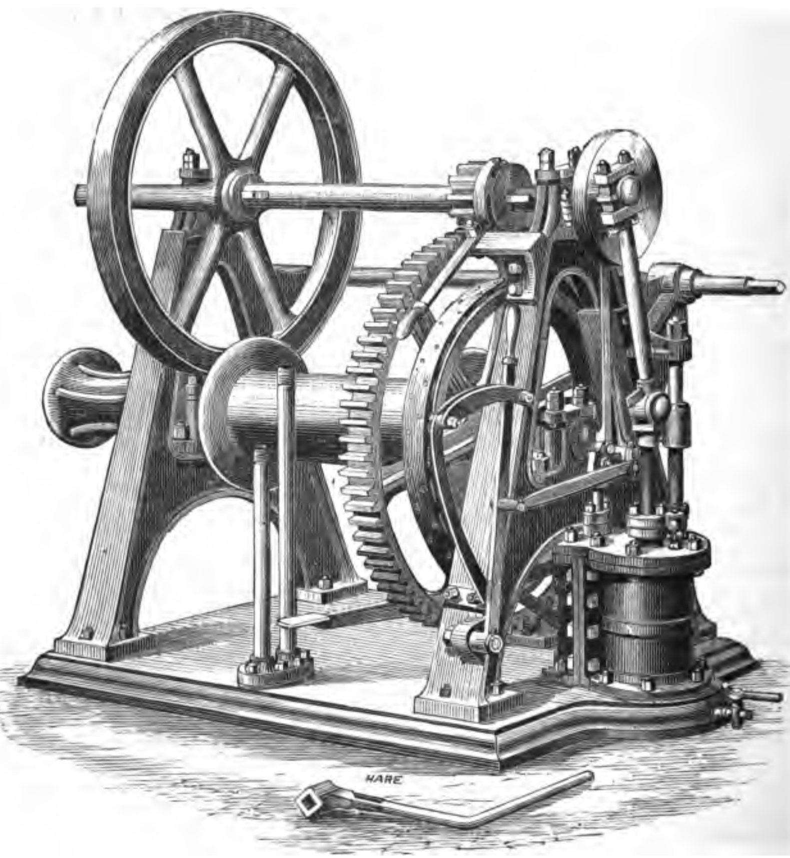


Fig. 205.

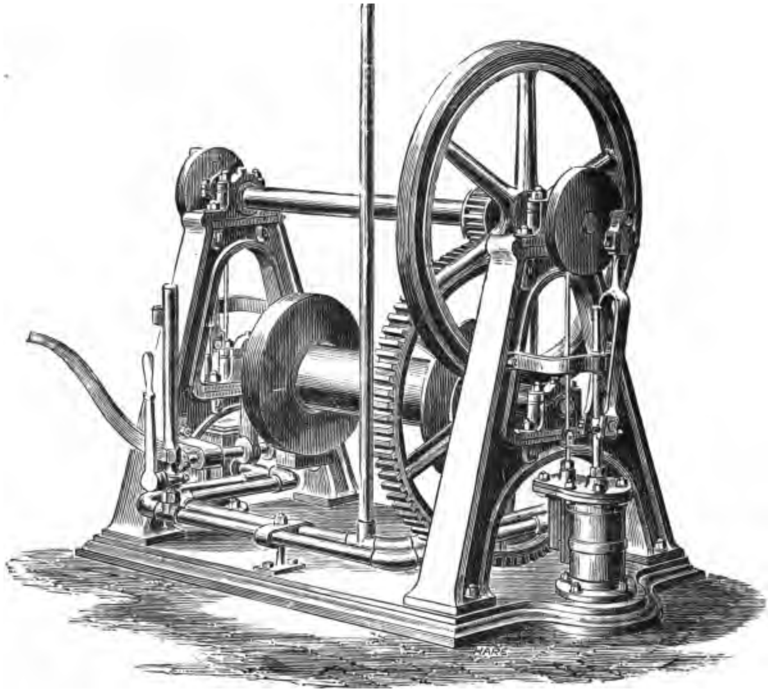


Fig. 206.

PRICES OF STEAM WINCHES, Figs. 205 and 207.

Power of winch in tons	1	1½	2
Number of cylinders and diameter	1—6½″	2—5½″	2—6½″
Price without link motions..	£65	£75	£80
Price with link motions	£70	£85	£90
Approximate weight in cwts.	29	36	45
„ measurement in cubic ft.	114	150	180

The cost of boilers complete with all furnace and steam fittings is—

For one single-cylinder winch			£40
For one 2-ton double-cylinder winch			£50
For two 2-ton	ditto	ditto	£60
For one 5-ton	ditto	ditto, or }	£88
For two 3-ton	ditto	ditto }	

For further details and prices of boilers of other sizes, see pages 55 to 64, Section 1.

The cost of a steam donkey pump fitted to the boilers is from £10 to £15.

For use on board ship the boiler is often fixed on a wrought-iron tank, which contains the feed water and protects the deck. The extra cost of this is £12 to £18, according to the size of the boiler.

One of the winches is sometimes required to be fitted with a boiler feed pump in addition to the donkey; and this can be done at a cost of £10.

The cost of fixing these winches necessarily varies with the dimensions of the ship and the relative positions of the winches and boiler, and also whether the connections are of iron or

copper (copper is generally used in ships of the best class); the length of chimney, size of water tank, cost of delivery, travelling expenses, &c., must also be considered; but many pairs of the 3-ton winches have been fixed by the authors, and the cost, including extra length of boiler chimney, copper pipes with flanged connections, main stop valve and cock to each winch, and the wages and expenses of one man, has usually been about £45 to £50 per pair.

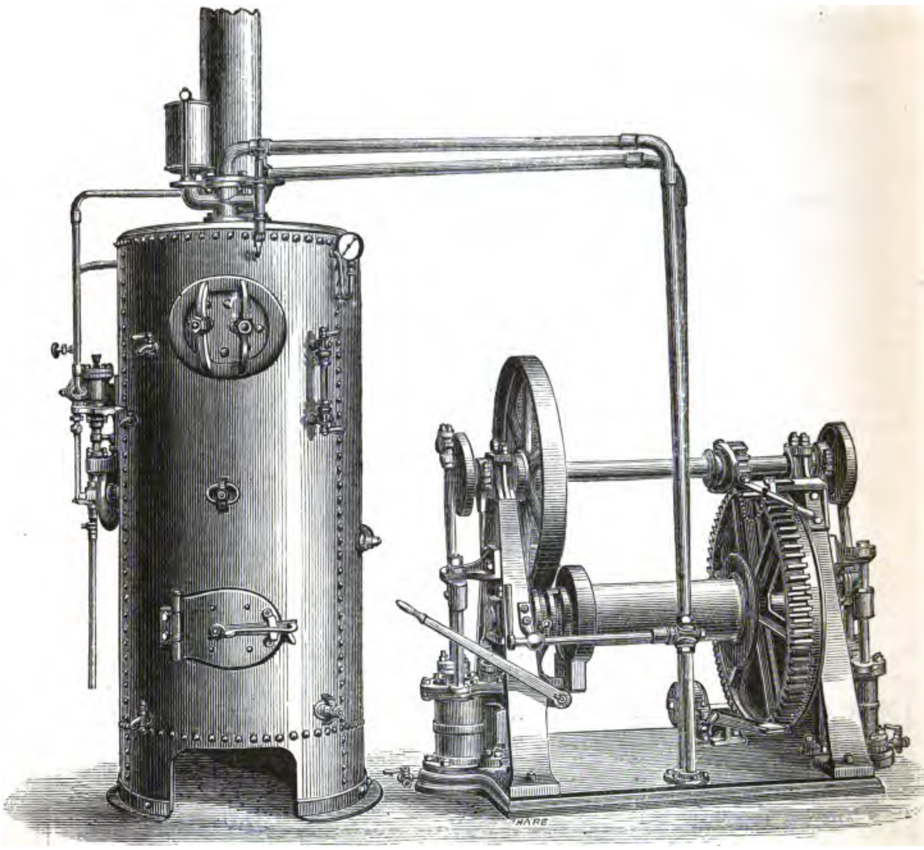


Fig. 207.

COAL-WHIPPING WINCHES. A special design is adopted for this work. The cylinders act directly on to the barrel, and an up-and-down rope is used; the engine and boiler are made separate, and are as light as possible, so that they can be taken in a boat alongside a sailing ship, and readily hoisted on board by the ship's tackle.

In some cases the whole of the winches required to work the cargo in and out of the ship are driven from one engine placed amidships by means of a high-speed cord carried along the deck, and protected by wood casings; but the results obtained do not show much economy either in first cost or in working expenses.

A small set of hydraulic machinery would probably meet the case in a much more perfect manner than the system above mentioned; and for vessels of great tonnage the same plant could be used for working the cranes, windlass, hydraulic steering gear, &c. The accumulator would be small, and weighted by steam instead of by the ordinary weight case.

But perhaps the most perfect and convenient arrangement would be to work the winches and other appliances referred to by compressed air, which gives off no vapour in exhausting into the

atmosphere, and which can be carried in pipes below the deck. This is scarcely admissible with steam pipes, because a slight leak would (and, indeed, has) caused very heavy loss to the owners.

A boiler and engine, with an air-compressing apparatus, would be fixed in any convenient position, and the air, compressed to about 40 lbs. per square inch, would be conducted in pipes in exactly the same way as if steam were used. The air-compressing machinery would sometimes render invaluable service in forcing fresh air into places which are inaccessible to any other means of ventilation, and the heat, moisture, and smell caused wherever a steam winch is worked would be avoided, the whole of these inconveniences being localised to where the engine and boiler are fixed.

STEAM STEERING GEAR. The application of steam power to steering vessels of great burden, especially the largest class of ocean-going steamers, is now considered almost essential, not only with a view of relieving the men from a most arduous part of their duty, but also for facilitating the handling of ships under critical circumstances in a manner which would be impossible with the slower operation of steering by manual power.

A pair of steam cylinders of suitable diameter are placed at an angle of 90° to each other on one of the side frames. Between the side frames is a chain wheel, over which a chain passes, guided by pulleys and connected to the rudder, the steam gear being usually placed amidships, on the main deck, and the steering wheel fixed on the top of the deck house or bridge: this wheel is connected by a light shaft and suitable toothed wheels to the eccentrics and valve gear on the crank shaft, and as the wheel is moved (which requires very little effort) on the bridge in either direction, the eccentrics are moved on the crank shaft, and the engines immediately move in unison, bringing the rudder up to any desired point. When the wheel is released the rudder comes back to its central position. In some cases a duplicate wheel is fitted on the main deck in addition to that on the upper deck, so that the steering gear can be worked from either position. Steam-steering gear is usually fitted to work by hand or by steam power at pleasure.

Gear for steamer of tons burden	1000	1500	2000	3000
Price with wheel and indicator at engine only	£150	£185	£235	£290
" " " on bridge only	£160	£195	£245	£300
" " " at engine and on bridge ..	£170	£205	£255	£310
Price extra with hand-steering gear in addition to the steam..	£30	£35	£40	£45
Approximate weight in tons	2	2¼	2½	3
" measurement in cubic ft.	100	125	150	200

CONTRACTORS' and BUILDERS' STEAM HOIST, Fig. 208. The general construction of this machine is practically the same as Figs. 188 and 189; the chief difference being that an ordinary chain-barrel is substituted for the winding drum which is required for wire rope. The framing is of rivetted wrought iron, or channel bars welded up at the corners, and the part under the boiler is plated top and bottom to form a water tank. This form of engine is very largely used instead of horses for hoisting barrows with an up and down chain on the barrel; the travelling wheels are plain or flanged, and they can be made to run at right angles with the engine shaft in the same way as is shown in Fig. 210, a cranked swivelling axle being used for each wheel; this is often extremely handy for moving along a jetty or pier, or for use on the top of an excavation.

The following data was obtained from the working of a number of these hoists used in the construction of the Thames Embankment:—The work to be done was lifting barrows containing the excavated materials a height of about 35 ft., and lowering an empty barrow at the same time as the full one was lifted. This was accomplished by a chain attached to each end of the chain-barrel, so that whilst one chain was being coiled on the barrel the other was un-coiling; each of these chains was led over a rubbish wheel suspended from a pair of legs steadied by guy ropes, but having sufficient play to allow the barrows to bear lightly against the guide planks in ascending, and when at the top the barrows were easily landed on the stage by slightly pulling over the legs.

In this instance, as in many others, the space available was so limited that it would have been almost impossible to employ horse runs to have done the same work. Each hoist could easily make 30 to 40 lifts per hour, and the average working expenses extending over several months, including all charges, was but 4*s.* 6*d.* per day, which shows very great economy over the old plan of working with horses.

When employed for hoisting building materials, the engine is usually put down in a central position, and the chains or ropes are carried away in opposite directions to the two extreme ends of the works, and there hoists the bricks, mortar, &c., in barrows on to the scaffolds, along which they are wheeled to serve the bricklayers. These hoists have been used by the con-

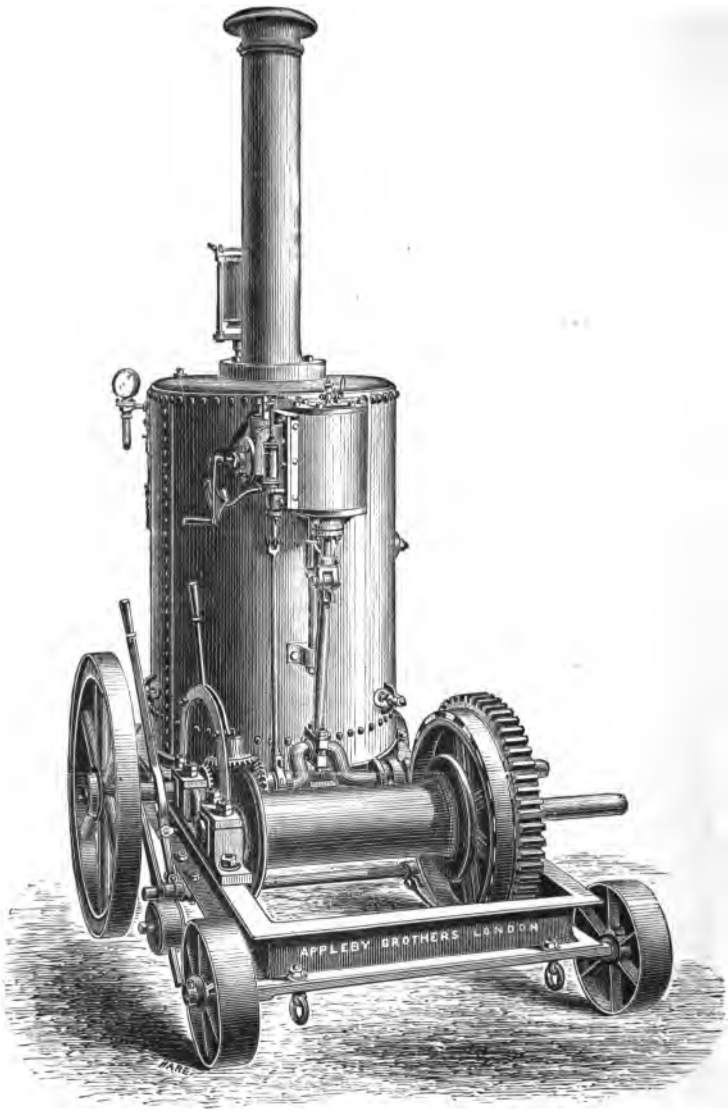


Fig. 208.

tractors for the erection of many of the large buildings in London; amongst which may be mentioned the Inns of Court Hotel, Grosvenor Mansions, Broad Street Station, London and Chatham Goods Depôt, &c. At the Inns of Court Hotel the engine also drove a small mortar mill: apart from the great saving in space and in horses, the men employed are kept well

served and get through more work than when the supply is intermittent; the profits from this source alone are estimated to have amounted on a large building to about £20 per week. The hoist, Fig. 208, has a quick speed of lifting gear only, but they are usually made with two speeds; one for work of the nature indicated above, and a slow speed for hoisting columns and girders, timbers, stones, &c.; the weight lifted direct from the barrel is about 15 cwt., and for heavier loads blocks and falls are used. The size employed for lifting barrows is 3-horse power nominal, but they are made up to 12-horse power, and with single or double cylinders. The ends of the shafts are extended, so that a capstan, a pump arm or pulley may be fitted for transmitting power for other purposes, and each engine has reversing gear and all the usual appliances.

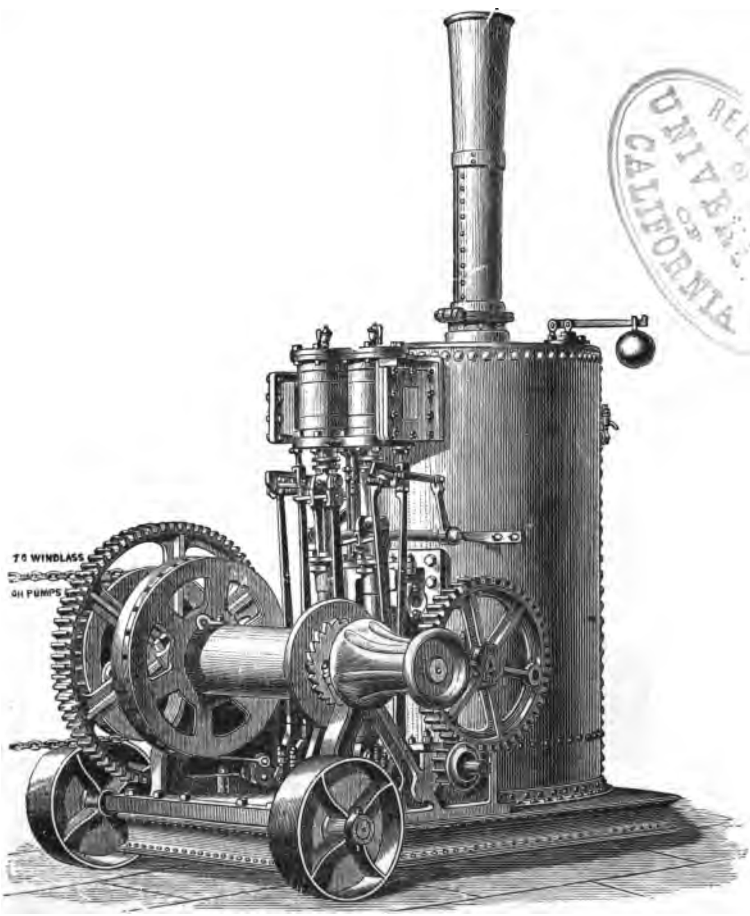


Fig. 209.

DOUBLE-CYLINDER HOIST, Fig. 209. The smallest size is 6-horse power; the engines can be fitted with double-purchase gearing for lifting weights up to 3 tons direct from the barrel.

Many hoists of the kind shown in Fig. 209 have been made for railways, docks, and harbours in this country and abroad, with wrought-iron side frames made from boiler plate strengthened with angle irons bent round and rivetted to the edges, the various shafts being carried in bosses rivetted to the side plates; this is a very good construction, but the cost is about 10 per cent. higher than is given in the subjoined list of prices:—

PRICES of STEAM HOISTS, Figs. 208 and 209.

Horse-power	3	4	6	8	12	6	8	12
No. and diameter of cylinders ..	1—5½"	1—6½"	1—7¼'	1—9"	1—11"	2—5½"	2—6½"	2—7¼"
Price, without wheels or reversing gear	£ 150	£ 180	£ 210	£ 230	£ 300	£ 220	£ 270	£ 340
Price extra with reversing gear ..	5	6	8	10	12	15	20	25
Price extra for plain or flanged wheels *with fixed axles*	5	5	6	8	10	6	8	10
Price extra for road wheels, locking plate, and shafts	10	10	15	20	25	15	10	25
Price extra for felting, lagging and casing boiler	8	10	12	15	18	12	15	18
Packing for shipment	5	6	7	8	10	7	8	10
Approximate weight in tons ..	3¼	3¾	4¾	6¼	7½	5	6¾	7¾
„ measurement ..								

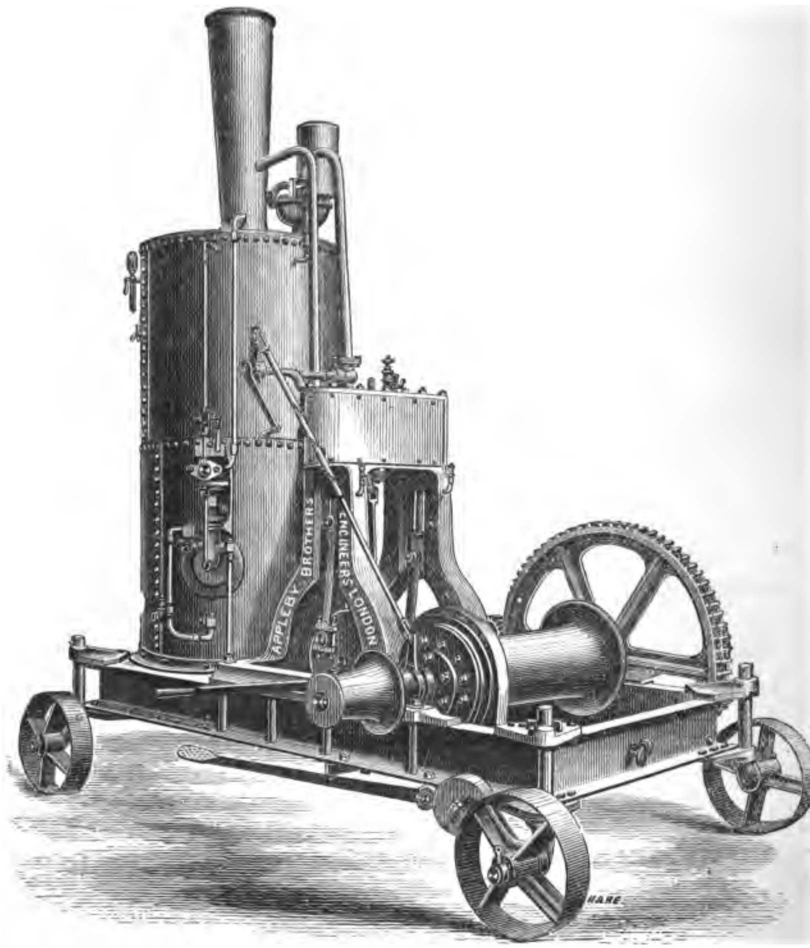


Fig. 210.

THE HOISTING ENGINE, Fig. 210, is capable of being used for the same purposes as Fig. 208, but the engines are the inverted-cylinder type, and of the same design as are used so largely for small steam launches and yachts, and are quite independent of the boiler. This construction is undoubtedly superior to that in Figs. 208 and 209, although in practice little or no trouble is experienced from the expansion of the boiler if the valves are set while steam is up, but it is better adapted for running at very high speeds, and the purpose (pile driving) for which the engines were originally designed demands almost an excessive speed. The system referred to, is that employed in Holland, and is explained in Section 4. The wheels have crank axles for running at right angles relatively with the crank shaft as mentioned p. 135; also the end of the hoisting barrel is fitted with an improved form of friction clutch which is not necessary for general work: but is invaluable for pile driving or well boring. Two sizes of engines are made, the smaller size has two 5-in. cylinders, and the larger two 6-in. cylinders, and the prices are £220 and £265 respectively.

HOIST DRIVEN BY POWER, Fig. 211. This is used for exactly the same description of work as the hoists, Figs. 208 and 209, but it is driven by any motive power, usually an ordinary portable engine, either direct from the crank shaft, or a number of them can be driven from a line of shafting fixed temporarily, the same motor and shaft being used for driving mortar pans, a saw bench, pump, or other machinery.

The hoist occupies a ground space of about 4 ft. × 5 ft.; the gearing is single and double purchase, and is mounted on a stiff cast-iron base plate, the principal shafts having gun-metal

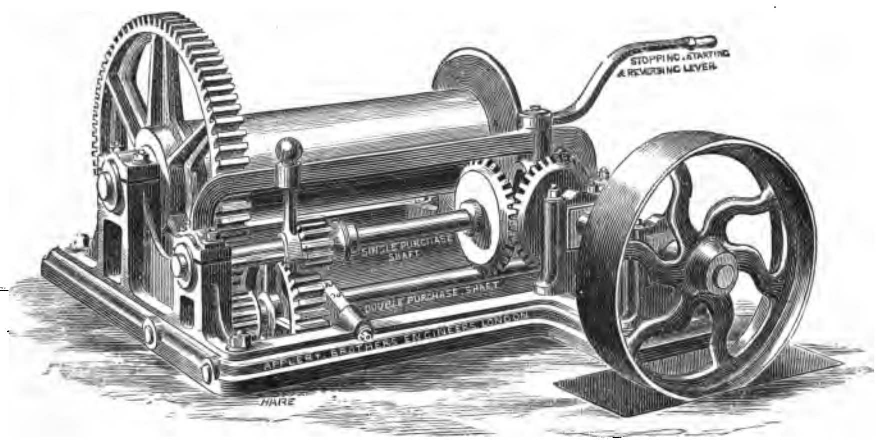


Fig. 211.

bearings with loose caps, and lock nuts. The driving pulley can be placed as shown, or on the axis parellel with the barrel; this is a great advantage when the space in which the hoist and engine have to be placed is limited, because they can be in line or at right angles to each other. The hoist is stopped or put in motion by one lever only which actuates a pair of cone friction clutches, the pulley shaft being driven continuously in one direction, and the brake is worked by a foot lever directly below the starting and reversing lever.

THE HOIST DRIVEN BY POWER, Fig. 212, is adapted for precisely the same duty as Fig. 211, but is of cheaper construction. A pair of cast-iron plates are bolted to a timber frame, and the various bosses bored out to receive the shafts; the reversing motion is obtained by using cross and open driving straps instead of friction clutches and mitre wheels. This hoist can only be driven in a direct line from the engine, and is not fitted with brass bearings. The hoists, Figs. 211 and 212, are proportioned to lift 10 cwt. at a high speed, or up to 20 cwt. in the double purchase at a slower speed direct from the barrel, and when required for loads above this limit, blocks are used, the end of the chain or rope fall being attached to the barrel. The usual practice is to have two chains on the barrel at one time as explained at p. 135, and to use them during the ordinary working hours, for hoisting the bricks, mortar, timber and light materials, and after the ordinary hours (or until an ample supply of materials has been

raised) to disconnect the light chains, and use blocks and fall to lift and set in position the columns and girders of the various floors or roof.

Price of hoist.	Fig. 211	£60
Weight	"	25 cwt.
Measurement	"	55 cub. ft.
Price of hoist.	Fig. 212	£40
Weight	"	16 cwt.
Measurement	"	48 cub. ft.
Extra for capstan to either	.. ..	£1

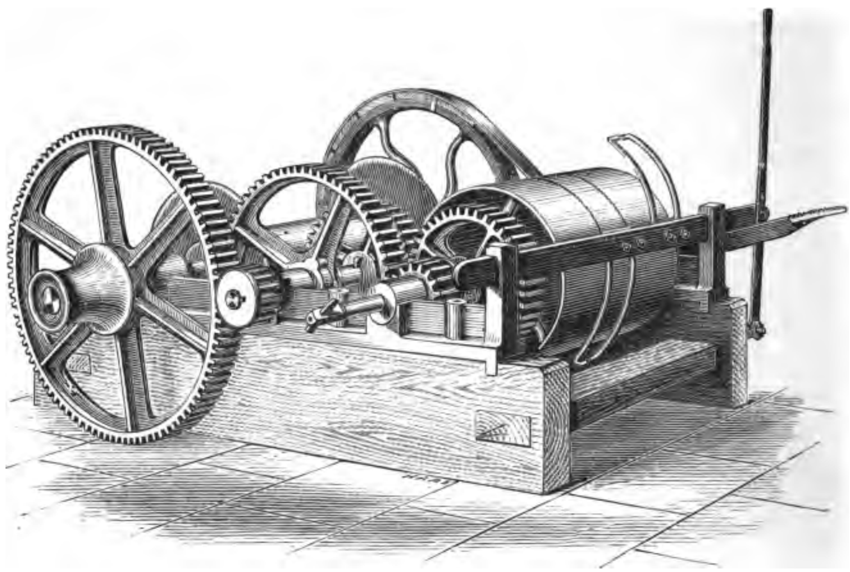


Fig. 212.

BUILDER'S HOISTS. A very useful hand-power builder's hoist is that invented by Messrs. Collins and Stanbury. This consists of a pair of light endless pitch chains working over a suitable pulley driven by a wheel and pinion, with a fly-wheel on the handle shaft. The whole is mounted on a light iron frame, and the method of using this apparatus is to run up a light vertical framing of ordinary scaffold poles equal to the height of the intended building, the gearing being fixed at the top; the chains reach within about 2 ft. of the ground, and a man is stationed on the top who keeps the chains constantly in motion; the hods of bricks or mortar are hooked on below and are taken off at any desired height as the building progresses, and the empty hods are hooked on to the descending side of the chain.

Another very excellent labour-saving machine, much used on the Continent, especially in France and Belgium, for erecting large stone buildings, consists of a wood framing very similar to a pile-driver framing, mounted on flanged wheels, and travelling on a pair of rails of about 10 ft. gauge, which is laid parallel to the front of the building in course of construction. The inner rail is laid about 5 ft. from the front, and is carried somewhat higher than the top of the building. A small portable engine, fixed on the base of the frame, transmits motion to suitable gearing for moving the frame on the rails, lifting the stones from the drays and (if already dressed when brought to the works) directly on the walls of the building. The facility and speed with which the various operations are performed, and the saving of a heavy and costly timber scaffolding of sufficient strength to carry heavy blocks, or a traveller, renders this machine worth the attention of builders and contractors in this country. The framing is bolted together, so that removal and re-erection are not difficult operations.

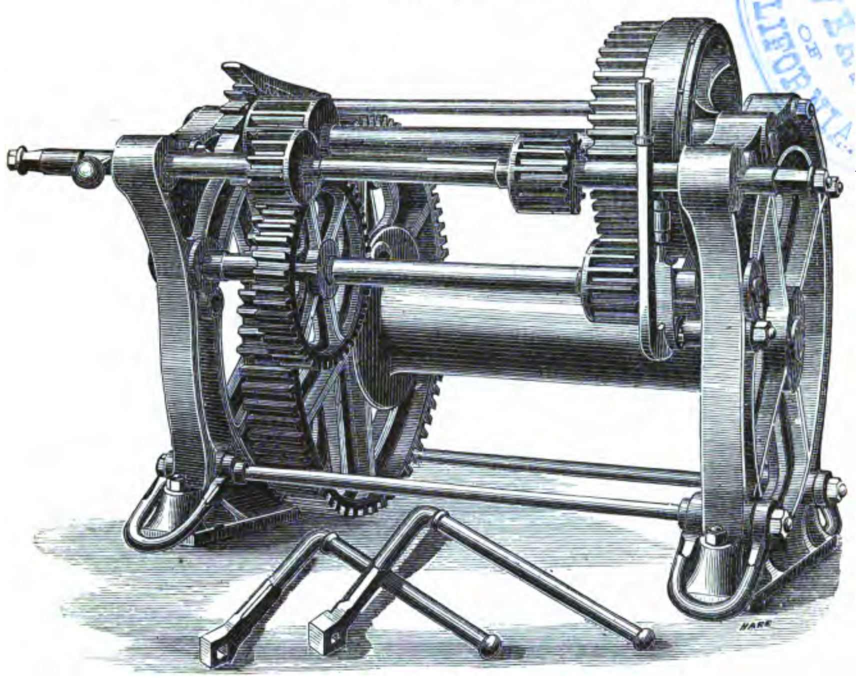


Fig. 213.

HAND-POWER WINCH. Fig. 213 is engraved from a photograph of the treble-purchase winches or crabs, designed by the Authors, and constructed for H.M. Government for moving the 81-ton gun into position at the proof butts at Woolwich and at Shoeburyness. The whole of the gearing is of the strongest form and proportions; the diameter of the shafts is increased where the wheels and pinions are keyed on, the full section of the shafts being thus preserved; the bearings throughout are of ample length, and are bushed with gun metal; the pawl and pawl wheel are of wrought iron, the pawl wheel being keyed on to the third motion shaft; the break wheel is cast to the third motion spur wheel, and is lined with wood and fitted with wrought-iron lever. The whole of the pinions, where possible, are flanged up to the points of the teeth. The large spur wheel is keyed direct on to the barrel, so as to relieve the barrel shaft from any torsional strain; the hand shaft is fitted with pawl for moving the shaft from double to treble purchase. The wrought-iron handles are fitted with loose brass quills, and made of a considerable length, so that four men can work at each handle. The bottom stays at each corner of the crab framing are fitted with heavy wrought-iron shackles, which are used for holding down the crab, or for attaching a snatch block when a lead other than from the barrel is required. These winches are calculated to lift 5 tons direct from the barrel, but there is a very large margin of safety. With double sheave blocks and fall, 25 tons may be lifted, or with 2 and 3 sheave blocks, 30 tons. The weight of each crab is 3 tons. The price is £70, or with shackles, £75.

Much larger hand-power crabs than that illustrated and described above, have been constructed by the Authors, and when the size and power exceed that of the 5-ton crab, it is usual to make it with entirely double sets of gear and spur wheels at each end of the barrel; by this means two hand shafts are obtained with a considerable distance between them, admitting of double the number of men being employed without any crowding at the handles, also the strain on the wheels and shafts is divided between two sets of gearing. The framing of the crab in this case is more rectangular in form, but the style of work throughout is similar to that above described.

A large number of crabs of this type are in use in the various Government Establishments.

THE HAND WINCH, Fig. 214, was also constructed for H.M. Government (War Department). The general design is the same as Fig. 213; but it is only proportioned to lift loads of 3 tons direct from the barrel, or 15 tons with 2 and 3-sheave blocks and falls. The gear is single and double purchase, and the handle shaft is fitted with loose and fast pulleys for power. One of

these crabs was placed on a large barge which was used as a floating shears for laying the concrete blocks required in the works which were so successfully completed, from the designs and under the superintendence of Sir Charles Hartley, at the Sulina mouth of the Danube, in accordance with the provisions of the Treaty of Paris (1856).

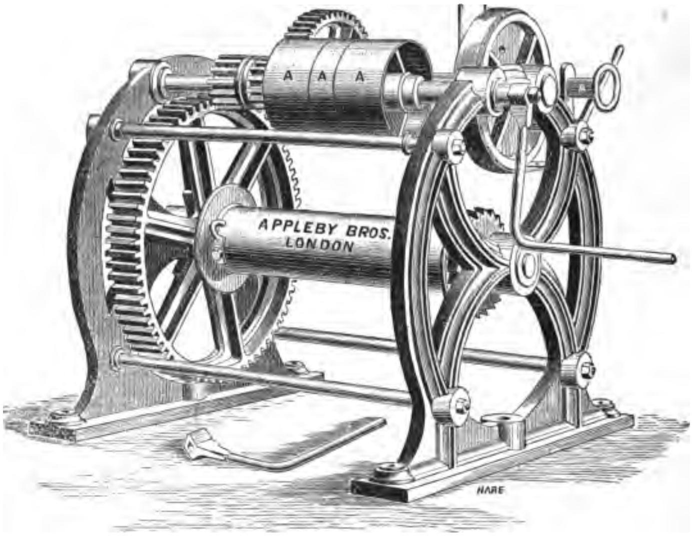


Fig. 214.

HAND WINCH, Fig. 215, differs slightly in construction from Fig. 213, and is calculated to lift two tons direct from the barrel. A large number of these crabs have been supplied to the various departments of H.M. and other Governments, and to many Railways and Dock Companies at home and abroad.

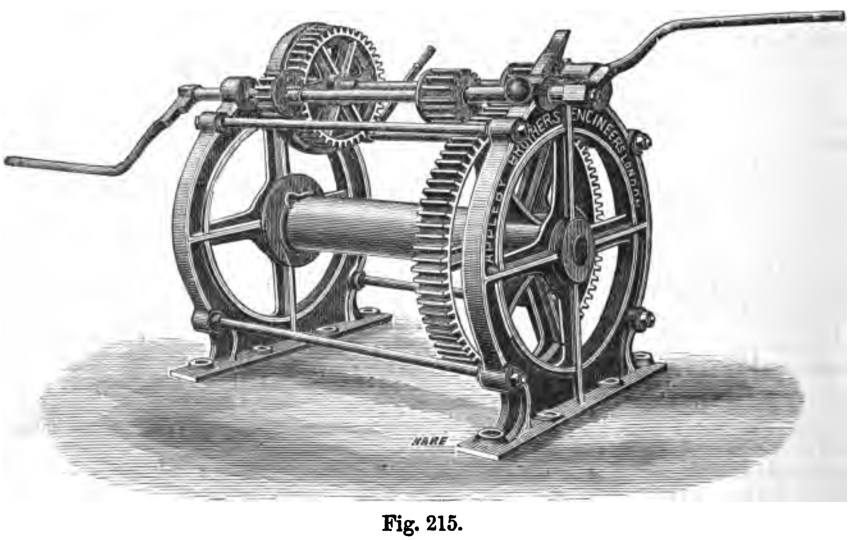


Fig. 215.

In calculating the powers given in the following Tables, it has been assumed that 2 and 3-sheave blocks and falls will as usual be employed; and if the lead is taken direct from the barrel, the power given in the Tables should be divided by 5. The result will be the weight

for which the crabs may be used with safety with a single rope or chain. The whole of the crabs are proportioned to lift the maximum loads with 25 lbs. per man at the handles.

PRICES of CRABS, Figs. 214 and 215.

Power of crab in tons	5	10	15	20
Price of crab	£25 0 0	£35 0 0	£48 0 0	£60 0 0
Price extra if with brass bearings ..	£3 0 0	£4 10 0	£7 0 0	£9 0 0
Price extra with pulleys	£4 0 0	£5 0 0	£6 0 0	£7 0 0
Price extra with capstan, each ..	£1 0 0	£1 5 0	£1 10 0	£1 15 0
Weight in cwts.	16	22	28	35
Measurement in cubic feet	65	80	100	125

The measurements given are for the crabs when sent away whole; the dimensions may be considerably reduced by taking them to pieces and packing a number together.

HAND WINCH, Fig, 216, is for crabs of moderate power, the weights and prices of which must be kept as low as possible; this is effected by making the barrel shorter and correspondingly reducing the lengths of all the shafts and stays, and by making the side frames smaller than in Fig. 215, which cover the largest spur wheel and protect it from breakage. The powers and strength of the gear are in the same proportion as Fig. 213, and where a great length of barrel is not required these crabs will do excellent service.

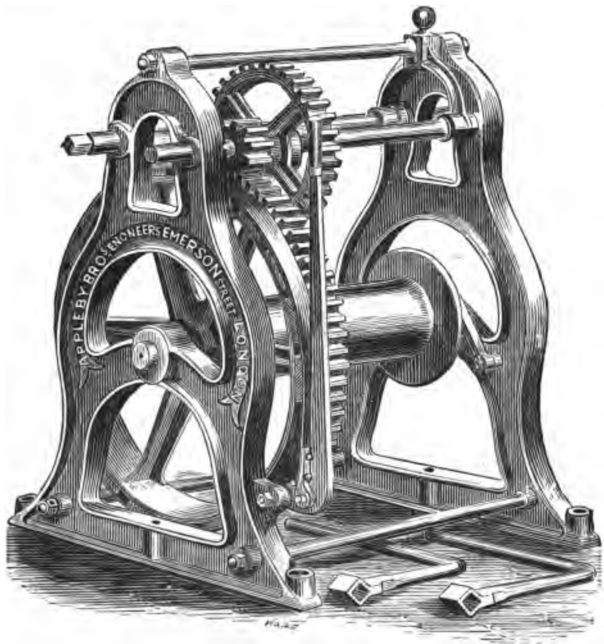


Fig. 216.

PRICES of CRABS, Fig. 216.

Power of crab in tons	3	5	10	15
Price of crab	£10 15 0	£13 10 0	£22 0 0	£32 10 0
Price extra for brass bearings ..	£1 12 0	£1 15 0	£2 0 0	£2 10 0
„ „ capstan ends, each ..	£0 10 0	£0 15 0	£1 0 0	£1 5 0
Weights in cwts.	$5\frac{3}{4}$	$8\frac{1}{2}$	11	$21\frac{1}{2}$
Measurement in cubic feet	48	50	60	90

HAND WINCHES WITH WROUGHT-IRON FRAMES. Figs. 217 and 218 are single and double-purchase crabs; the side frames are constructed of wrought-iron plates stiffened by angle irons, which are welded up and rivetted to the edges of the frames; the journals are carried in strong cast-iron bosses rivetted to the plates. The gearing is of the same proportion as that used in the crabs of corresponding power with cast-iron sides.

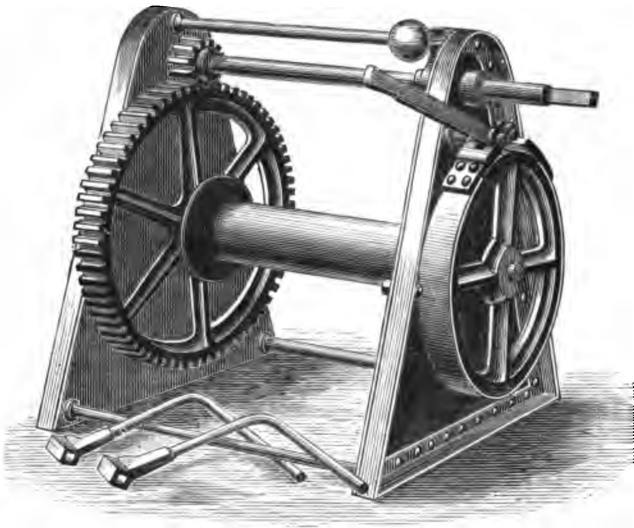


Fig. 217.

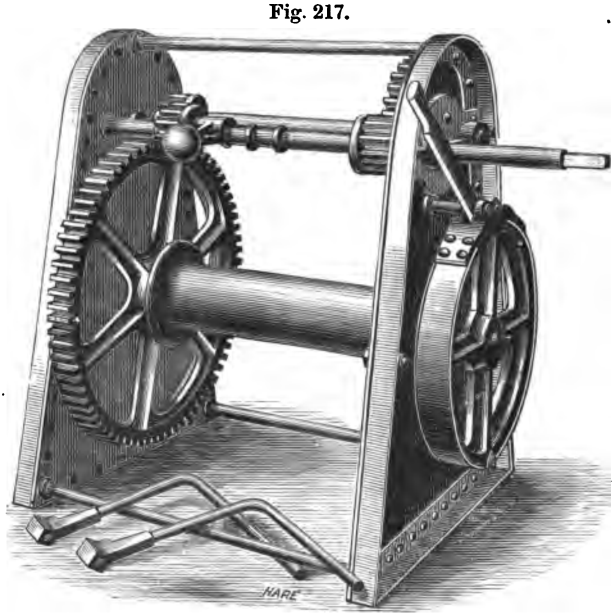


Fig. 218.

The winches shown were made to specification for the Oude and Rohilkund Railway Company, and the brakes were outside of the frames, but it is generally preferable to cast the brake to the large spur wheel, which, being inside the frame, is protected from breakage by rough handling. In many places where repairs cannot be effected the first cost of a crab is of little importance provided that it cannot be broken by rough usage; in such cases the wheels are made of malleable iron, machine moulded. The cost is necessarily higher, but the extra outlay may perhaps guard against the accidents which so frequently happen to this kind of machinery.

Steel wheels and pinions are also used where the first considerations are to reduce the weight for transport and to insure immunity from breakage.

The cost of these crabs with steel or malleable cast-iron wheels is about 25 per cent. above the prices in the subjoined list.

PRICES OF WROUGHT-IRON FRAME CRABS, Figs. 217 and 218.

Power of crab in tons	1	2	3	4	5	10
Single or double purchase	Single.	Double.	Double.	Double.	Double.	Double.
Price of crab	£10	£12	£14	£16	£18	£25
Approximate weights in cwts. ..	5	6	7	8	9	12
" measurement cub. ft.	24	30	35	40	45	60

LIGHT HAND WINCHES, Figs. 219 and 220. Fig. 219 is a light double-purchase crab, or winch, for builders' and masons' work, where small loads are required to be lifted by one man, and being light it is easily moved from place to place.

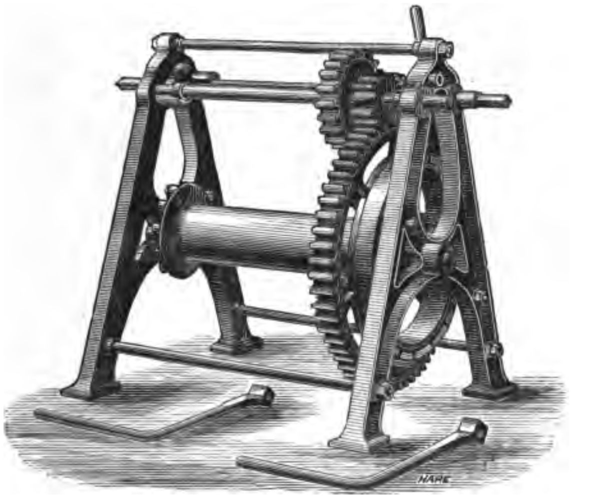


Fig. 219.

The side frames are of considerable strength, the flanges being double and of a good depth; the journals are of ample length accurately bored out in position, and the shafts are turned throughout. The brake wheel is turned on the face, and the brake strap is lined with wood; the pawl wheel is cast to the end of the barrel and fitted with wrought-iron pawl; two handles are supplied.

Fig. 220 is similar in design, but is fitted with single-purchase gear and a fly-wheel.

If the crab is required to work with a crane jib, as shewn in Fig. 133 p. 47, for high lifts, the momentum given by the fly-wheel greatly assists the attendant, both in the amount of work performed and in the time occupied.

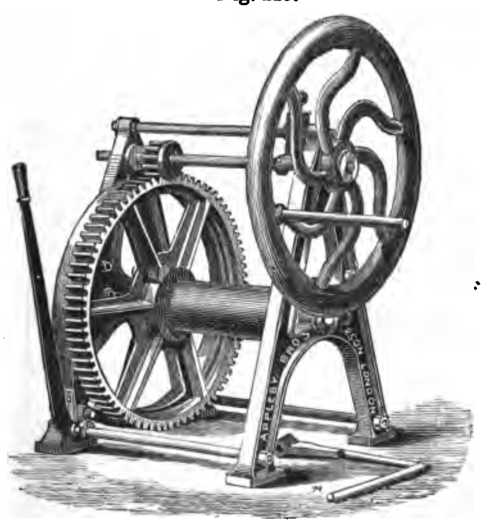


Fig. 220.

The side frames are quite equal in strength and size to the double-purchase crab, Fig. 219, the same height to the turning centre being necessary for a light and single-purchase crab as for heavier and more powerful crabs; this is a point which is frequently lost sight of, and many small power crabs are made which are only about 18 ins. from base to the turning point, instead of being 36 ins., and the importance of making lifting machinery as handy as possible is thus sacrificed in the endeavour to save a few shillings in first cost.

Price of 2-ton double-purchase crab, Fig. 219	£7 10 0
„ extra, if fitted with gun-metal bushes	£1 12 0
„ „ „ fly-wheel	£2 0 0
Approximate weight, without fly-wheel, in cwts.	5
measurement in cubic feet	28
Price of 1-ton single-purchase crab, Fig. 220	£6 15 0
„ extra for gun-metal bushes in hand shaft	£1 0 0
„ „ „ fly-wheel, as shown	£2 0 0
Approximate weight, without fly-wheel, in cwts.	5
„ measurement in cubic feet	24

Fig. 221.

Fig. 222.

Fig. 223.

Fig. 224.

PULLEY BLOCKS. Figs. 221 to 224 are of the kind known as the "London pattern," and are made of the best scrap iron with a strong and well-proportioned hook and turned cast-iron sheaves.

If gun-metal sheaves are substituted for the usual cast-iron sheaves, the prices given below will be increased 30 to 50 per cent. In ordering pulley blocks, it is advisable to state whether they are required for ropes or for chains.

Diameter of sheave	3"	3½"	4"	4½"	5"	6"	7"	8"	9"	10"
" chain	3/16"	¼"	¼"	5/16"	5/16"	⅜"	7/16"	9/16"	⅝"	⅝"
Girth of rope	2¼"	2⅝"	3"	3⅜"	3¾"	4⅛"	4½"	5¼"	6"	6¾"
Price 1 sheave, Fig. 221 ..	8/6	11/	14/6	17/	19/6	30/	36/	48/	60/	72/
" 2 " Fig. 222 ..	11/	13/	17/	19/6	21/6	36/	48/	72/	96/	120/
" 3 " Fig. 223 ..	13/	17/	19/6	24/	26/6	48/	60/	96/	120/	168/
" 4 "	17/	19/6	24/	30/	36/	72/	84/	108/	144/	192/
" snatch blocks, Fig. 224 ..	14/6	18/	21/	24/	28/6	32/6	42/	54/	66/	78/

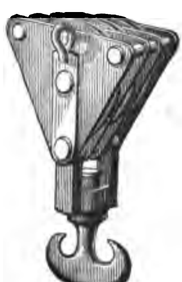


Fig. 225.

The **PULLEY BLOCKS**, Fig. 225, are of great strength, and are adapted for lifting heavy guns, or other great weights. The sheaves are made extra wide, and the prices are:—

Diameter of sheave	9"	12"	12"	18"
To lift, tons	15	20	25	30
Size of chain	⅝"	¾"	⅞"	1"
Price 1 sheave	60/	84	96/	144/
" 2 "	120/	156/	168/	192/
" 3 "	144/	192/	204/	240/

Fig. 226.

GIN BLOCKS, WHIP GINS, RUBBISH PULLEYS, or MONKEY WHEELS, Fig. 26, fitted with wrought-iron frames and hooks, and cast-iron sheaves.

Diameter of pulley ..	3"	4½"	6"	7"	8"	9"	10"
Price each	2/6	3/	4/	4/6	5/	7/6	9/6
Diameter of pulley ..	11"	12"	14"	16"	18"	20"	22"
Price each	12/	13/6	14/6	17/	19/	22/	24/

TABLE FOR CALCULATING THE SIZES AND LIFTING POWERS OF PULLEY BLOCKS.

Diameter of sheave	3"	3½"	4"	4½"	5"	6"	7"	8"	9"	10"	12"	18"
Width of groove	7/16"	½"	⅝"	¾"	⅞"	1"	1¼"	1½"	1¾"	2"	2½"	4"
Each sheave to lift, cwts. ..	2	3	5	6½	10	12	18	27	35	48	75	150

To ascertain the size and number of sheaves required to lift a given weight, divide the weight to be lifted by any weight in the above Table; the result will give the number of sheaves and sizes of blocks required.

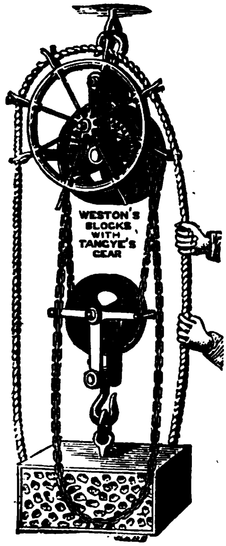


Fig. 227.

EXAMPLE.—If 60 cwt. is to be lifted, either of the following combinations will be suitable:—

A pair of 3 and 3 sheaves, ⅞ in. at 10 cwt. per sheave or } 60 cwt.
" 2 " 3 " 1 " 12 " }

Note.—The powers given above are approximately correct; but a sufficient margin should always be allowed.

DIFFERENTIAL PULLEY BLOCKS (WESTON'S).

Tested to	5 cwt.	10 cwt.	12 cwt.	20 cwt.
Price of blocks per set	12/6	20/	20/	30/
If fitted with spocket wheel ..	..	..	..	..
Bright chain per foot	/6	/6	/7	/9
Tested to	30 cwt.	40 cwt.	60 cwt.	80 cwt.
Price of blocks per set	40/	50/	100/	120/
If fitted with spocket wheel ..	..	75/	110/	135/
Bright chain per foot	/10	/11	1/1	1/3

WESTON'S BLOCKS WITH TANGYE'S PATENT GEAR, Fig. 227.

Tested to	4 tons	5 tons	6 tons	8 tons	10 tons
Price of blocks per set ..	135/	200/	240/	320/	400/
Bright chain per foot ..	1/3	1/6	2/4	3/	3/6

PATENT HAND HOIST (Moore and Head's Patent). This block or hoist is specially constructed to enable one man to raise heavy weights with ease and rapidity. It is so arranged that the man can check it without difficulty when the weight is falling. It is simple in arrangement, strong in construction, and easy to move about. It can be fixed to any beam or bar, and supplied with chain for any length of lift; and is specially suitable for mills, warehouses, builders' purposes, brewers, farmers, &c. It is (when ordered) fitted with an effective brake, by which means the load, when being lowered, is entirely under the control of the man.

Lifting power	2½ cwt.	5 cwt.	10 cwt.	15 cwt.	20 cwt.
Price	£1 10 0	£1 15 0	£2 10 0	£3 5 0	£4 0 0
" hand chain per foot	/7	/7	/7	/11	/11
" lifting chain "	/7	/7	1/3	1/8	1/8
" if fitted with brake	15/	15/	20/	25/	30/

PATENT SACK HOISTS, Fig. 228. These hoists are well adapted for lifting light loads rapidly into granaries, warehouses, and stores. They are supplied, when required, with an effective brake, which is of great advantage in lowering into carts, &c. It will be seen from the engraving that the construction is exceedingly simple: two wheels of different diameters are cast together, the smaller one carrying the lifting chain, the larger wheel the endless chain, and by this arrangement great power is obtained. The speed and power of the 5-cwt. hoist is equal to 5 to 1, and the 20-cwt. size 15 to 1.

The height of lift should always be given when ordering.

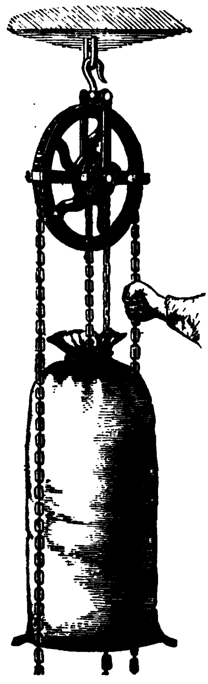


Fig. 228.

Lifting power	3 cwt.	5 cwt.	10 cwt.	20 cwt.
Price of hoists	30/	35/	45/	65/
Prices of chains per foot including rings or hooks	/7	/7	/8	/8
Extra for brake	15/	20/	20/	20/

PATENT SAFETY HOIST, Fig. 229, has been designed for use where great care in lowering is required. On reversing the main wheel the load begins to descend at a moderate speed, and is kept in motion by occasionally pulling at the rope. If the load be allowed to run it will check itself gradually until it stops, and if the rope is suddenly "let go" whilst lifting, the load will remain in suspense in its then position.

Fig. 229.

The spocket-wheel is about 24 inches in diameter, and the distance between beams about 16 inches.

Price to lift 2½ cwt.	£4
Chain with one hook	5s. per foot.
Rope	3½d. ,,

If required to lift 5 cwt., add the cost of a single sheave pulley, 5s.

PATENT DOUBLE-LIFT SAFETY HOIST (Weston's Patent). This hoist is self-sustaining. When the hand rope is released, the load remains in suspense. The lowering is effected by pulling the rope on the other side of the wheel. The chain has two hooks, one descending while the other ascends, so that when one hook reaches the top, the other is at the bottom ready for another load, thereby losing no time in running the empty hook up and down. One man can lift the weight, and by hooking up the end of the chain and using a single-sheave pulley block in the loop thus formed, double the weight can be lifted. In ordering, the height of lift should be stated.

To lift, cwts	2½	5
Price of hoist	£3 0 0	£7 10 0
Best tested chain per foot ..	0 0 7	0 0 10
Rope per foot	0 0 4	0 0 4
One-sheave pulley block ..	0 5 0	0 7 6

HYDRAULIC LIFTING JACK, Fig 230. These Jacks lift either from the foot or top, are simple in action and construction, very safe and portable, and so arranged that one man can lift from 4 to 60 tons.

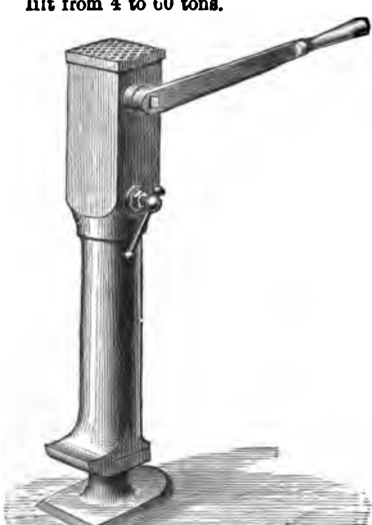


Fig. 230.

To lower, unscrew the top valve in the side of the head of the Jack, when the fluid will return to the reservoir.

To lift, tons ..	4	6	8	10	12
Height	23″	24″	25″	26″	26″
Will run out ..	10″	10″	11″	12″	12″
Weight, lbs. ..	57	68	76	86	96
Price	£5	£6	£7	£8	£9

To lift, tons	15	20	30	40	50	60
Height ..	26″	28″	28″	28″	28″	28″
Will run out	12″	12″	12″	11″	11″	10″
Weight, lbs.	104	132	174	206	264	364
Price ..	£10 10	£12 10	£17	£20	£22	£25

HYDRAULIC TRAVERSING JACK. This Jack is made to traverse in the same manner as is shown in Fig. 232, and the prices, mounted on wrought-iron frame, and including ratchet lever, are—

All sizes from 4 to 12 tons ..	£3 extra to above.
,, ,, 12 to 20 tons ..	£5 ,, ,,

The **HYDRAULIC SHIP JACK**, Fig. 231, is suitable for lifting ships, girders, bridge work, and other unusually heavy loads. The pump and cistern can be detached from the ram for being worked at any distance from the weight to be raised, or several rams can be worked from one pump.

Fig. 231.

To lift, tons	20	35	50	70	100	150	200
Will run out	6″	7″	7″	7″	7″	7″	7″
Height when down ..	12″	14″	14″	14″	14″	14″	14″
Price	£12	15	18	21	22 10	28	33

If with safety valve attached to indicate pressure, £2 5s. extra.

TRAVERSING SCREW JACKS, Fig. 232, with double ratchet lever to main screw:—

Will lift, tons	6	8	12	15	20
Height when down	20″	24″	26″	27″	27″
Will traverse	6½″	9″	12″	16″	22″
Prices	£6 10	£7	£7 15	£9 15	£12 5

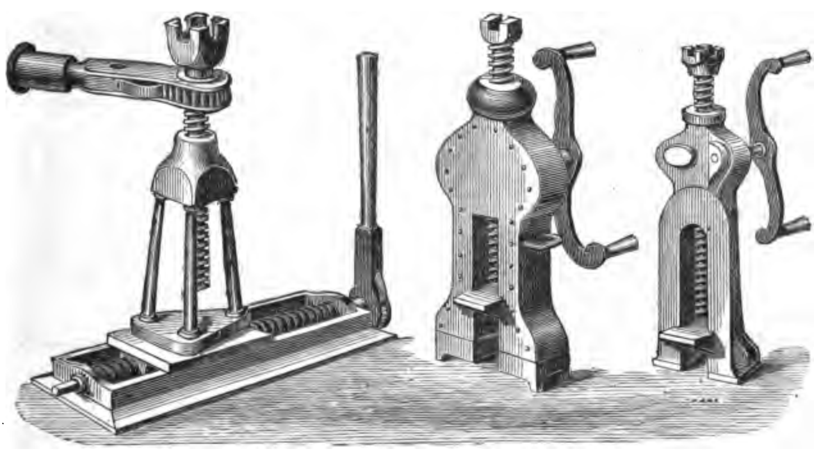


Fig. 232. Fig. 233. Fig. 234.

HALEY'S SCREW JACKS, Fig. 233, in wood case, and Fig. 234, in malleable iron case:—

Will lift, tons .	2	4	6	8	10	12	16	20
Will run out ..	13″	13″	13″	13″	13″	14″	14″	15″
Prices	£4 10	£5	£5 15	£7	£8	£9	£15	£18 10

RACK and PINION JACK, Fig. 235 :—

	Single Purchase.			Double Purchase.			
Will lift, tons	2	3	3	3	4	6	8
Height when down ..	30″	30″	36″	30″	30″	31″	33″
Prices	£5 10	£6 10	£7 10	£7	£7 10	£8 10	£9 10

RATCHET SCREW JACK, Fig. 236, with wrought-iron frames :—

Will lift, tons	6	8	10	12
Height when down	21″	24″	27″	30″
Prices	£3 17 6	£4 10	£5 7 6	£6 10

BOTTLE JACK, with cast-iron frames, Fig. 237.

Will lift, tons	1½	2	4	5	6	8	10
Height when down ..	12″	15″	18″	21″	24″	24″	24″
Prices	£0 17 6	£1	£1 2 6	£1 6	£1 10	£2	£2 10

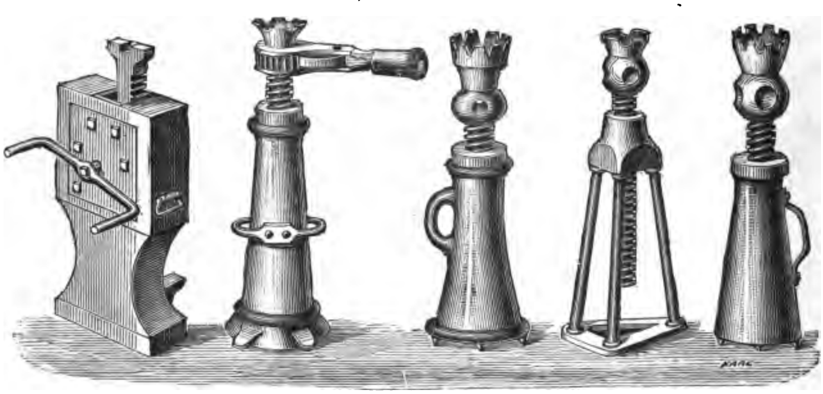


Fig. 235. Fig. 236. Fig. 237. Fig. 238. Fig. 239.

TRIPOD and BOTTLE JACKS, Figs. 238 and 239 (or cotton screw) :—

Will lift, tons ..	1½	2	3	4	5	6
Height when down .	9″	12″	15″	18″	21″	24″
Prices	£1 4	£1 7 6	£1 12	£1 18 6	£2 5	£3

Will lift, tons ..	8	10	12	14	16	18
Height when down .	27″	30″	33″	36″	42″	48″
Prices	£3 13	£4 10	£5 10	£6 7 6	£6 17 6	£7 15

USEFUL TABLES AND MEMORANDA RELATING TO HOISTING MACHINERY.

PRICES AND WEIGHTS OF BEST TESTED SHORT-LINK CRANE CHAINS.

Size of chain	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$
Approximate weight per foot in lbs. ..	1.33	1.91	2.33	3.25	3.66
Proof strain in cwts.	36.75	45.0	65.5	75.0	102.0
Working load in cwts.	20.0	24.0	27.0	44.0	53.0
Price per cwt.	33/6	29/6	25/6	24/9	24/-
Price per foot	-/4¾	-/6	-/7	-/8½	-/9¼

Size of chain	$\frac{3}{4}$	$\frac{7}{8}$	1	1⅛	1¼
Approximate weight per foot in lbs. ..	5.33	6.71	9.33	11.9	14.5
Proof strain in cwts.	147.0	200.0	268.0	334.0	408.0
Working load in cwts.	80.0	110.0	140.0	180.0	220.0
Price per cwt.	22/6	21/6	20/6	20/-	20/-
Price per foot	1/1	1/3	1/8½	2/1½	2/7

COMMON CHAIN, for ordinary purposes, 4/- per cwt. less than above prices.

PRICES, WEIGHTS, WORKING LOADS, AND BREAKING STRAINS OF ROUND IRON WIRE ROPES.

Circumference in inches	1	1½	1¾	2	2¼	2½	2¾
Weight per yard in lbs.	0.5	1.0	1.00	1.75	2.25	2.75	3.25
Working load in cwts.	6	9	15	21	27	33	39
Breaking strain in cwts.	40	60	100	140	180	220	260
Prices per cwt.	42/-	40/-	40/-	38/-	38/-	38/-	40/-

Circumference in inches	3	3¼	3½	3¾	4	4½	5
Weight per yard in lbs.	3.75	4.25	5.25	6.0	7.0	9.0	11.0
Working load in cwts.	45	51	60	72	84	108	125
Breaking strain in cwts.	300	340	400	480	560	720	900
Prices per cwt.	40/-	36/-	40/-	40/-	40/-	40/-	40/-

GALVANISED IRON WIRE ROPE 5/6 per cwt. more than above prices.

PRICES, WEIGHTS, WORKING LOADS, AND BREAKING STRAINS OF ROUND STEEL WIRE ROPES.

Circumference in inches ..	1	1¼	1½	1¾	2	2⅛	2¼	2⅜
Weight in lbs. per yard ..	0.5	0.75	1.0	1.25	1.75	2.0	2.25	2.50
Working load in cwts. ..	9	15	21	27	33	39	45	51
Breaking strain in cwts. ..	60	100	140	180	220	260	300	340
Prices per cwt.	65/-	60/-	60/-	60/-	55/-	55/-	53/-	53/-

PRICES, WEIGHTS, WORKING LOADS, AND BREAKING STRAINS OF ROUND STEEL WIRE ROPES.
(Continued.)

Circumference in inches	$2\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{1}{4}$	$3\frac{3}{8}$	$3\frac{5}{8}$	$3\frac{3}{4}$	4
Weight in lbs. per yard	2.75	3.25	4.25	4.50	5.25	6.0	7.0
Working load in cwts.	60	72	84	90	100	115	126
Breaking strain in cwts.	400	480	560	600	720	840	960
Prices per cwt.	52/-	51/-	51/-	51/-	51/-	51/-	51/-

PRICES, WEIGHTS, WORKING LOADS, AND BREAKING STRAINS OF BEST HEMP ROPES.

Circumference in inches	$2\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{2}$	6	$6\frac{1}{2}$
Weight per yard in lbs.	1.0	2.0	2.5	3.5	4.5	5.0
Safe working load in cwts.	6	12	18	24	30	36
Breaking strain in cwts.	40	80	120	160	200	240
Price per cwt.	68/-	68/-	68/-	68/-	68/-	68/-
Circumference in inches	7	$7\frac{1}{2}$	8	$9\frac{1}{2}$	10	
Weight per yard in lbs.	6.0	7.0	8.0	11.0	12.5	
Safe working load in cwts.	42	48	54	78	84	
Breaking strain in cwts.	280	320	360	520	560	
Price per cwt.	68/-	68/-	68/-	68/-	68/	

PRICES, WEIGHTS, AND STRENGTHS OF FLAT ROPES OF IRON, STEEL, AND HEMP.

Working load in cwts.	44	52	60	64	72	80
Breaking strain in cwts. ..	400	460	540	560	640	720
Size of tarred hemp rope ..	$4''\times1\frac{1}{8}''$	$5''\times1\frac{1}{4}''$	$5\frac{1}{2}''\times1\frac{3}{8}''$	$5\frac{3}{4}''\times1\frac{1}{2}''$	$6''\times1\frac{1}{2}''$	$7''\times1\frac{7}{8}''$
Weight per foot, good quality, in lbs.	3.3	4.0	4.3	4.6	5.0	6.0
Price per cwt.	63/-	63/-	63/-	63/-	63/-	63/-
Size of iron wire rope	$2\frac{1}{4}''\times\frac{1}{4}'$	$2\frac{1}{2}''\times\frac{1}{2}''$	$2\frac{3}{4}''\times\frac{5}{8}''$	$3''\times\frac{5}{8}''$	$3\frac{1}{4}''\times\frac{5}{8}''$	$3\frac{1}{2}''\times\frac{5}{8}''$
Weight per foot in lbs. ..	1.8	2.2	2.6	2.7	3.0	3.33
Price per cwt.	48/-	48/-	48/-	44/-	44/-	44/-
Size of steel wire rope	—	—	—	$2''\times\frac{1}{2}''$	$2\frac{1}{4}''\times\frac{1}{2}''$	$2\frac{3}{8}''\times\frac{1}{2}''$
Weight per foot in lbs... ..	—	—	—	1.7	1.85	2.0
Price per cwt.	—	—	—	70/-	70/-	70/-
Working load in cwts.	88	100	112	128	136	
Breaking strain in cwts. ..	800	900	1000	1120	1200	
Size of tarred hemp rope ..	$8\frac{1}{4}''\times2\frac{1}{8}''$	$8\frac{1}{2}''\times2\frac{1}{4}''$	$9''\times2\frac{1}{2}''$	$9\frac{1}{2}''\times2\frac{3}{8}''$	$10''\times2\frac{1}{2}''$	
Weight per foot, good quality, in lbs.	6.6	7.5	8.3	9.1	10.0	
Price per cwt.	63/-	63/-	63/-	63/-	63/-	
Size of iron wire rope	$3\frac{3}{4}''\times\frac{11}{16}''$	$4''\times\frac{11}{16}''$	$4\frac{1}{4}''\times\frac{3}{4}''$	$4\frac{1}{2}''\times\frac{3}{4}''$	$4\frac{5}{8}''\times3\frac{3}{4}''$	
Weight per foot in lbs... ..	3.7	4.2	4.7	5.4	5.7	
Price per cwt.	44/-	40/-	40/-	40/-	40/-	
Size of steel wire rope	$2\frac{1}{2}''\times\frac{1}{2}''$	$2\frac{3}{4}''\times\frac{3}{8}''$	$3''\times\frac{3}{8}''$	$3\frac{1}{4}''\times\frac{3}{8}''$	$3\frac{1}{2}''\times\frac{3}{8}''$	
Weight per foot in lbs... ..	2.2	2.5	2.75	3.0	3.4	
Price per cwt.	70/-	70/-	70/-	70/-	70/-	

CRANES. To ascertain the strains on the three principal members of a crane similar in construction to that shown in Fig. 127, construct a diagram of the crane to any convenient scale as shown in Fig. 240. The crane taken for example is of 2-tons power, 14′ 0″ radius, post 5′ 0″ above the ground line, and the jib at an angle of 45°.

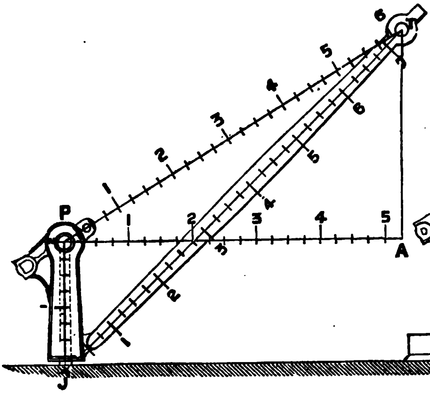


Fig. 240.

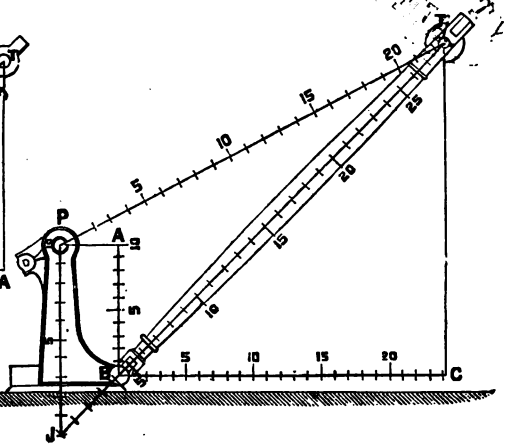


Fig. 241.

From P and T, Fig. 240, draw the horizontal and vertical lines cutting each other at A. The centre line of the post P J is divided into 8 equal divisions, each division = 5 cwt., or 5×8=40 cwt., the power of the crane; the strains on the tension or tie rods may then be measured off with a scale or pair of compasses, as indicated on the diagram, the strain on the tension rods P T being 124 cwt., the compression on the jib J T 148 cwt., and the strain on the post J P is shown on the line P A = 113 cwt., the post being regarded as a beam or cantilever loaded at one end and supported at the other.

To find the strains on the post, jib and tension rods of a ten-ton crane, with a roller path, similar to Fig. 126, the method shown in Fig. 241 should be adopted.

To find the strains of the jib and tie rods, the centre line of the jib must be continued down through the roller path until it cuts the centre line of the post, and from the intersection of these lines at J the divisions representing 10 tons must be set off; on the line J P the strains on the tie rods and jib are measured off as before; but for the post, a line parallel to the centre line of the crane post must be drawn from the point A to B, the load being set off on this; the strain on the head of post will be found by measuring the line B C, the angle A B C being regarded as a bell crank hinged at B.

To find the number of revolutions the handles of a hand-power crane will have to make to lift a given weight, the power on the handles being given :—

W = Weight to be raised, in lbs.
P = Power on handles, in lbs.
D = Diameter of circle described by the handles, in inches.
n = Number of revolutions of the handles to one of chain barrel.
B = Diameter of chain barrel, in inches.

$$B = \frac{D \times P \times n}{W} \qquad n = \frac{W \times B}{D \times P} \qquad D = \frac{W \times B}{P \times n} \qquad P = \frac{W \times B}{n \times D} \qquad W = \frac{P \times D \times n}{B}.$$

The height of the handles for hand-power cranes should be 2′ 10″ to 3′ 0″ from the ground line or platform on which the men stand to work, and the radius of handles should be 14″ to 16″.

The usual allowance for the power exerted by each man at a crane handle of 16″ radius is 25 lbs. for intermittent work, but not more than 15 lbs. for continuous work.

The speed at which a man will turn a crank handle is from 25 to 30 revolutions per minute = about 200 ft.

The above rules for finding the powers of a crane do not include any allowance for friction; 50 per cent. should be allowed for this.

Formula for Ascertaining the proper Diameters of Crane Posts.

D = Diameter of post, in inches.
W = Strain at top of post, in tons (found by the diagrams).
S = Distance or span from top of base-plate to the point of intersection of centre line of post and tension rods.
M = Margin of safety; this should be 5 for wrought iron, and 7 for cast iron.
K = Constant, which is 4.4 for wrought iron, and 6.6 for cast iron.
C = Internal diameter, in inches, of hollow cylindrical post (this must be assumed).

$$D = \sqrt[3]{K\ M\ W\ S} \text{ for solid crane posts.}$$

$$D = \sqrt[3]{(K\ M\ W\ S) + C^3} \text{ for hollow crane posts.}$$

Formula for Calculating the Strength of Trussed Beams.

W = Weight distributed.
L = Span of truss or girder.
l = Distance of struts or tie from point of support.
D = Depth of strut.
A = Angle of inclination with horizon.
S = Strain on centre of horizontal beam.
s = Strain on tie rods.

Single Truss.

$$S = \frac{W\ L}{8\ D} = \frac{W}{4} \text{ cotan. A.}$$

$$s = S\ \frac{\sqrt{L^2 + (2\ D)^2}}{L} = \frac{W}{4} \text{ cosect. A.}$$

Ordinary Queen Truss.

$$S = \frac{L\ W}{8\ D} \qquad s = \frac{S\sqrt{l^2 + D^2}}{l} = S \text{ sect. A.}$$

The loads on traveller beams should be taken at the centre; the results obtained by the above rules must therefore be divided by 2, and the usual factor allowed for the safe working loads.

WROUGHT-IRON AND STEEL GIRDERS. The maximum working strain usually allowed for wrought-iron girders in compression is 4 tons per square inch; in tension 5 tons per square inch: the Board of Trade, however, allows 5 tons per square inch for iron, or 6½ tons for steel, in compression or in tension.

D = Depth of girder, in inches.
A = Area of bottom flange, in square inches.
S = Span of girder, in inches.
B W = Breaking weight.
f = Resistance of material in tons per square inch.

$$B\ W = \frac{4\ A\ D f}{S} \text{ for girders supported at both ends and load in the centre.}$$

$$B\ W = \frac{8\ A\ D f}{S} \text{ for girders supported at both ends and the load distributed.}$$

Area of top flange should equal 1.18 of bottom flange.
Depth of girder should equal $\frac{1}{12}$ to $\frac{1}{13}$ of the span.

CAST-IRON GIRDERS. When the load on the girder is downwards, the bottom flange should be three times the area of the top one.

If the strain or load be applied upwards, the top flange should be twice the area of the bottom one.

D = Depth, in inches.
A = Area of bottom flange, in square inches.
S = Span of girder in inches.
W = Breaking weight, in tons.

$$\frac{26\ A\ D}{S} = W \text{ supported at both ends with load at centre.}$$

$$\frac{52\ A\ D}{S} = W \text{ supported at both ends with load distributed.}$$

Depth of cast-iron girders at ends may be $\frac{2\ D}{3}$.

Safe deflection one-tenth of an inch per foot span for a load of one-third the calculated breaking weight.

TABLE OF BREAKING WEIGHT OF CAST-IRON GIRDERS 10′ 0″ to 35′ 0″ span.

Span	10′ 0″	15′ 0″	20′ 0″	25′ 0″	30′ 0″	35′ 0″
Depth	0′ 10″	1′ 3″	1′ 8″	2′ 1″	2′ 6″	2′ 11″
Dimensions of bottom flange	6″ × 1¼″	8″ × 1½″	10″ × 1½″	13″ × 1¾″	15″ × 2″	17″ × 2″
Breaking weight in tons distributed	31	50	62	94	125	141

GEARING.

Relative pitch required to obtain the same strength in wheels made of different materials.

Cast iron	= 1.00
Brass	= 1.12
Hardwood	= 1.26
Good malleable cast iron	= 0.85
Phosphor bronze	= 0.80
Wrought iron	= 0.75
Cast-steel casting about	= 0.70
„ forging	= 0.50

The teeth of wood gear should be 1.25 times thicker at the pitch line than the iron teeth with which they gear. Brass wheels stand sudden strain better than cast iron.

To find the actual horse-power that can be transmitted by toothed gearing.

B = Breadth of tooth, in inches.
P = Pitch „ „
V = Velocity of pitch line in feet per second.
H = Actual horse-power which may be transmitted by the wheel.

$$H = .06\, P^2 V B. \qquad P = \sqrt{\frac{H}{\cdot 06\, V B}}.$$

To find the number of teeth in pinions to give a certain number of revolutions to a driving wheel.

N = Number of teeth in driving wheel.
n = „ „ pinion.
V = Number of revolutions in driver.
v = „ „ driven.

$$n = \frac{N V}{v}.$$

To find the diameter of the pitch line of a toothed wheel, the number of teeth and pitch being given.

D = Diameter of pitch line, in inches.
N = Number of teeth.
P = Pitch of teeth, in inches.
x = Multiplier (in Table).

$$D = P x \qquad P = \frac{D}{x}.$$

To find x in Table for any other number of teeth.

$$x = \text{Cosecant}\left(\frac{180^\circ}{N}\right).$$

To find the number of teeth when the diameter and pitch are given, divide the diameter by the pitch, which gives x, and take N from the Table.

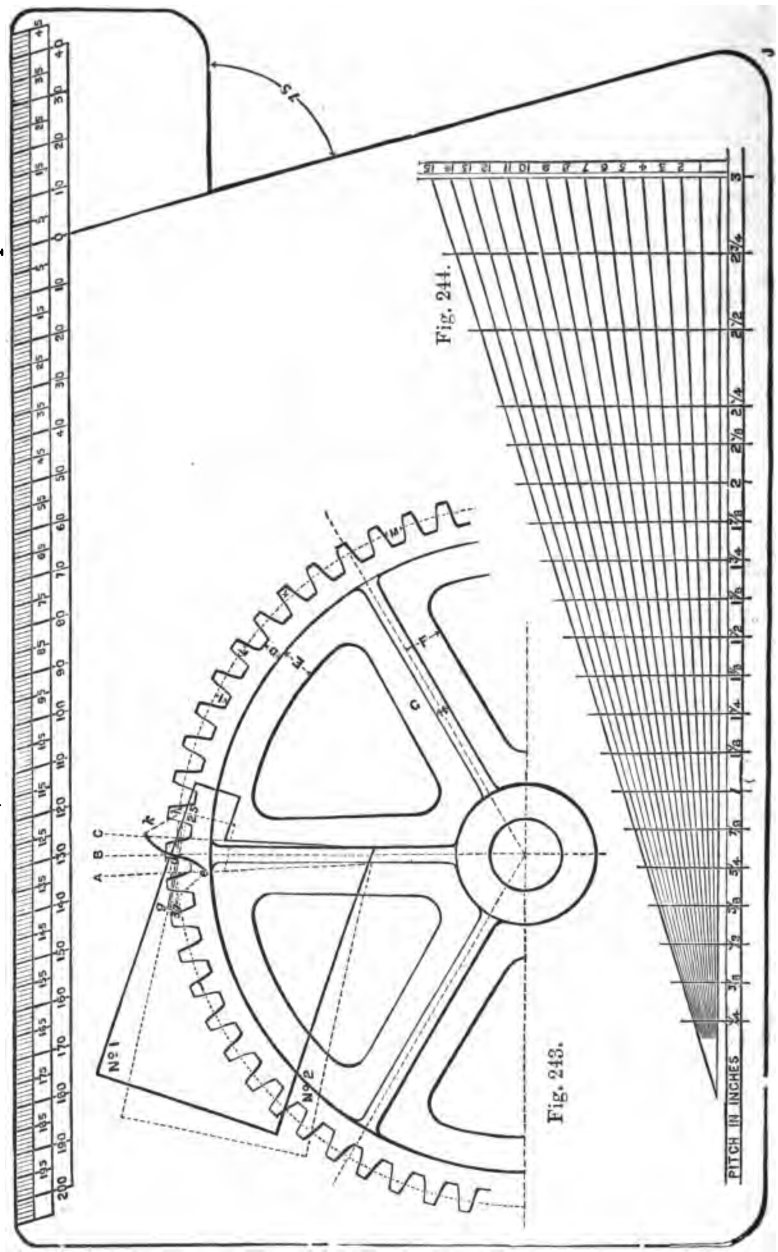


Fig. 242.

TEETH OF WHEELS. Few subjects connected with mechanical details have occupied the attention of engineers and mathematicians more than the form of the teeth of geared wheels, and the mode of producing such curves as will absorb the least amount of the power to be transmitted by the friction of the surfaces in contact, and work smoothly and (as far as possible) noiselessly.

The epicycloidal form of tooth is the most perfect; but the curves are too complicated to be properly set out by an average pattern-maker or draughtsman. This consideration led Professor Willis to design the instrument illustrated, Fig. 242, which he called the Odontograph. By using this very useful instrument and the annexed tables, the circular tops and roots of teeth can be readily drawn, and, considering the shortness of the arc, the shape of the tooth approximates very closely to the true epicycloidal form, and is quite correct enough for all practical purposes.

The engraving, Fig. 242, is exactly half the full size; and an instrument for temporary use can easily be set out from it on stiff drawing paper. The instrument and tables can, however, be purchased for about ten shillings.

The scale is divided into twentieths of an inch on each side of the line I J, which is drawn at an angle of 75° with the scale.

The engraving, Fig. 243, shows how the instrument is used. The wheel selected as an example has 61 teeth, 3-inch pitch. Having found the diameter of the pitch line of the wheel required, by the formula or the Table of Multipliers, p. 158, and this diameter being described, set out A C = to the pitch of the tooth, and draw the radial dotted lines as shown; bisect these by another radial line B. For the root of the tooth, place the instrument as indicated in No. 1, and in the Table for the Roots of Teeth opposite 60, which is the number nearest to that required, and in the column for 3-inch pitch, will be found 37. This point must be pricked off at *g*, and the arc *d e* described. This gives the proper form for the root of the tooth. The instrument is then moved into the position indicated by the dotted lines No. 2; and 25 being the number given opposite to 60 in the column for 3-inch pitch in the Table for Tops of Teeth, this point is pricked off as above described, and from the point *h* the arc *k d* is described. This gives the proper form for the top or face of the tooth.

When fixing the points *g* and *h*, it must always be remembered that they will be found on *opposite* sides of the radial arm of the instrument.

INTERNAL GEAR. In setting out internal gear the rule is inverted, the curve for the root becoming that which is given for the top in the foregoing instructions for using the instrument.

RACK GEAR. For setting out racks the pitch line becomes a straight line, and the instrument is applied to perpendiculars drawn on it equal to the pitch.

The numbers for pitches not given in the Tables may be found by doubling or dividing the numbers of a given pitch. As examples, if 4-inch pitch is required, double the number given for 2-inch pitch; or if $\frac{1}{2}$-inch pitch is required, take half that given for 1-inch pitch.

The diagonal scale, Fig. 244, gives the proportions of the various parts of wheels. These proportions give good results for wheels of ordinary dimensions; but modifications are required for very small or very large wheels.

I = Depth of tooth below pitch line = $\frac{6}{13}$ P.
K = Height ,, above ,, .. = $\frac{5}{13}$.
L = Breadth ,, ... = $\frac{7}{15}$.
M = Width of space between teeth = $\frac{8}{15}$.
D = Thickness of rim below the teeth = $\frac{7}{13}$ P.
E = Depth of rib of rim .. .. = 1 P.
F = Width of arm from feather .. = 1 P.
G H = Thickness of metal .. .. = $\frac{7}{16}$.

CENTRES FOR THE ROOTS OF TEETH.

No. of Teeth.	Pitch in inches.							
	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3
13	129	160	193	225	257	289	321	386
14	69	87	104	121	139	156	173	208
15	49	62	74	86	99	111	123	148
16	40	50	59	69	79	89	99	191
17	34	42	50	59	67	75	84	101
18	30	37	45	52	59	67	74	89
20	25	31	37	43	49	56	62	74
22	22	27	33	39	43	49	54	65
24	20	25	30	35	40	45	49	59
26	18	23	27	32	37	41	46	55
30	17	21	25	29	33	37	41	49
40	15	18	21	25	28	32	35	42
60	13	15	19	22	25	28	31	37
80	12	15	17	20	23	26	29	35
100	11	14	17	14	22	25	28	34
150	10	13	16	19	21	24	27	32
Rack	10	12	15	17	20	22	25	30

CENTRES FOR TOPS OR FACES OF TEETH.

No. of Teeth.	Pitch in inches.							
	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3
12	5	6	7	9	10	11	12	15
15	5	7	8	10	11	12	14	17
20	6	8	9	11	12	14	15	18
30	7	9	10	12	14	16	18	21
40	8	9	11	13	15	17	19	23
60	8	10	12	14	16	18	20	25
80	9	11	13	15	17	19	21	26
100	9	11	13	15	18	20	22	26
150	9	11	14	16	19	21	23	27
Rack	10	12	15	17	20	22	25	30

TABLE OF MULTIPLIERS

For finding the Diameter of Pitch Lines of Wheels, the Pitch and number of Teeth being given.

N	x	N	x	N	x	N	x
8	2.6131	32	10.2023	56	17.8308	80	25.4713
9	2.9238	33	10.5224	57	18.1505	81	25.7963
10	3.2360	34	10.8396	58	18.4718	82	26.1096
11	3.5495	35	11.1584	59	18 7893	83	26.4304
12	3.8637	36	11.4737	60	19.1073	84	26.7595
13	4.1789	37	11.7913	61	19.4254	85	27.0645
14	4.4941	38	12.1100	62	19.7431	86	27.3989
15	4.8097	39	12.4240	63	20.0653	87	27.7076
16	5.1258	40	12.7454	64	20.3862	88	28.0238
17	5.4421	41	13.0642	65	20.7050	89	28.3471
18	5.7587	42	13.3838	66	21.0212	90	28.6537
19	6.0757	43	13.6975	67	21.3339	91	28.9923
20	6.3924	44	14.0207	68	21.6561	92	29.3134
21	6.7093	45	14.3355	69	21.9742	93	29.6160
22	7.0268	46	14.6589	70	22.2873	94	29.9515
23	7.3449	47	14.9709	71	22.6094	95	30.2680
24	7.6612	48	15.2897	72	22.9255	96	30.5638
25	7.9787	49	15.6085	73	23.2509	97	30.8931
26	8.2959	50	15.9259	74	23.5695	98	31.2012
27	8.6137	51	16.2491	75	23.8802	99	31.5184
28	8.9318	52	16.5617	76	24.1994	100	31.8362
29	9.2494	53	16.7143	77	24.5273	120	38.2015
30	9.5667	54	17.1984	78	24.8463	150	47.7491
31	9.8842	55	17.5134	79	25.1550	180	57.2986

TABLE OF HORSE-POWER

that can be transmitted per inch in width of Teeth of various Pitches and Speeds.

Velocity in ft. per second.	Pitch of Teeth in inches. Cast-iron Wheels.										
	¾ H.P.	1 H.P.	1¼ H.P.	1½ H.P.	1¾ H.P.	2 H.P.	2½ H.P.	3 H.P.	4 H.P.	5 H.P.	6 H.P.
0.25	.008	.015	.023	.033	.045	.060	.093	.135	.240	.370	.540
0.50	.017	.030	.047	.067	.090	.12	.180	.270	.430	.750	1.08
0.75	.025	.045	.070	.101	.138	.18	.281	.400	.720	1.12	1.62
1.00	.033	.06	.094	.135	.184	.24	.375	.540	.960	1.50	2.16
2.	.067	.12	.188	.270	.366	.48	.750	1.08	1.90	3.00	4.30
3.	.10	.18	.28	.40	.550	.72	1.10	1.60	2.80	4.50	6.40
4.	.13	.24	.37	.54	.730	.96	1.50	2.10	3.80	6.00	8.60
5.	.17	.30	.47	.67	.910	1.20	1.80	2.70	4.80	7.50	10.80
6.	.20	.36	.56	.81	1.10	1.40	2.20	3.20	5.70	9.00	12.90
7.	.23	.42	.65	.94	1.28	1.68	2.60	3.70	6.70	10.50	15.10
8.	.27	.48	.75	1.10	1.40	1.90	3.00	4.30	7.60	12.00	17.20
9.	.30	.54	.84	1.20	1.60	2.10	3.30	4.80	8.60	13.50	19.40
10.	.33	.60	.94	1.35	1.80	2.40	3.70	5.40	9.60	15.00	21.60
12.	.40	.72	1.10	1.60	2.10	2.80	4.50	6.40	11.50	18.00	25.90
14.	.47	.84	1.30	1.80	2.50	3.30	5.20	7.50	13.40	21.00	30.20
16.	.54	.96	1.50	2.10	2.90	3.80	6.00	8.60	15.30	24.00	34.50
18.	.61	1.1	1.70	2.40	3.30	4.30	6.70	9.70	17.30	27 00	38.90
20.	.66	1.2	1.90	2.70	3.60	4.80	7 50	10.80	19.20	30.00	43.20
22.	.74	1.3	2.10	2.90	4.00	5.30	8.20	11.90	21.10	33.00	47.50
24.	.81	1.4	2.20	3.20	4.40	5.70	9.00	12.90	23.00	36.00	51.80
26.	.88	1.5	2.40	3.50	4.70	6.20	9.70	14 00	24.90	39.00	56.10
28.	.95	1.6	2.60	3.70	5.10	6.70	10.50	15.10	26.90	42.00	60.40
30.	1.01	1.8	2.80	4.00	5.50	7.20	11.20	16.20	28.80	45.00	64.80
35.	1.2	2.1	3.30	4·70	6.40	8.40	13.10	18.90	33.60	52.50	75.60
40.	1.3	2.4	3.70	5.40	7.30	9.60	15.00	21.60	38.40	60.00	86.40